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(54) Title: PLANT TRANSCRIPTION REGULATORS FROM CIRCOVIRUS

(57) Abstract

The present invention is directed to transcription regulators and transcription regulator-like sequences of circovirus origin. As used in the specification, the circovirus group is considered to include subterranean clover stunt virus (SCSV) coconut foliar decay virus (CFDV), banana bunchy top virus (BBTV), milk-vetch dwarf virus (MDV) and faba bean necrotic yellow virus (FBNYV). The transcription regulators and transcription regulator-like sequences of the instant invention are useful in genetic engineering of plants and in particular leguminous plants such as to facilitate or control expression of foreign genes. The transcription regulators and transcription regulator-like sequences of the present invention are also useful in facilitating different levels of expression in different plant tissue types.

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PLANT TRANSCRIPTION REGULATORS FROM CIRCOVIRUS

- 5 The present invention relates generally to a novel range of transcription regulators and transcription regulator-like sequences operable in plants. More particularly, the present invention is directed to transcription regulators and transcription regulator-like sequences of viral origin and, even more particularly, of circovirus origin. The transcription regulators and transcription regulator-like sequences of the instant invention are useful
- 10 in genetic engineering of plants and in particular leguminous plants such as to facilitate or control expression of foreign genes. The transcription regulators and transcription regulator-like sequences of the present invention are also useful in facilitating different levels of expression in different plant tissue types.
- 15 Bibliographic details of the publications referred by author in this specification are collected at the end of the description. Sequence Identity Numbers (SEQ ID Nos.) for the nucleotide sequences referred to in the specification are defined following the bibliography.
- 20 Throughout this specification, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element or integer or group of elements or integers but not the exclusion of any other element or integer or group of elements or integers.
- 25 Transcription regulators are molecules, and generally nucleotide-based molecules, which facilitate and modulate expression of genetic sequences at the level of transcription. Transcription regulators include promoters and termination and polyadenylation sequences amongst other effectors and facilitators of transcription.
- 30 Promoters are specific nucleotide sequences to which RNA polymerase binds to initiate RNA synthesis in cells. They contain the start site for RNA synthesis and the genetic signals to initiate polymerase mediated RNA synthesis. In addition, sequence specific

- DNA-binding proteins are presumed either to inhibit or to stimulate the initiation of RNA synthesis by binding next to the promoter and affecting the binding of the polymerase to the promoter. Terminator sequences refer to termination and polyadenylation sequences and are required for transcription of functional mRNAs.
- 5 Termination sequences are located downstream (i.e. at the 3' end) of a gene and are recognized by RNA polymerase as a signal to stop synthesizing mRNA. Polyadenylation sequences are signals required for polyadenylation of eukaryotic mRNA molecules following transcription.
- 10 A viral promoter widely used to facilitate foreign gene expression in plants is the cauliflower mosaic virus (CaMV) 35S promoter (Odell *et al.* 1985), which is derived from a double-stranded DNA plant virus. The use of this promoter in plants and plant cells is well documented (Benfey and Chua, 1990; Higgins and Spencer, 1991). However, despite the apparent usefulness of this promoter, it is not functional in all
- 15 plants and is particularly poorly operable in leguminous plants. There is a need, therefore, to identify other promoters, such as of viral origin, which are operable in plants and particularly leguminous plants. There is also a need to modulate levels of expression of genes and other genetic sequences within plant cells.
- 20 Accordingly, one aspect of the present invention is directed to a genetic construct comprising a circovirus promoter or promoter-like sequence and which is operable in a plant cell.
- In a related aspect of the present invention, there is provided a genetic construct
- 25 comprising a circovirus promoter or promoter-like sequence and a termination and/or polyadenylation sequence, which sequences are operable in a plant cell.
- A circovirus is a non-geminated single stranded (ss) DNA plant virus (Table 1), distinct from caulimoviruses which have a double stranded genome, and geminiviruses, the only
- 30 other known ssDNA plant viruses, which have geminated particles (Chu *et al.*, 1994). As used herein, the circovirus group is considered to include subterranean clover stunt virus (SCSV) (Chu and Helms, 1988), coconut foliar decay virus (CFDV) (Rohde *et al.*

1990), banana bunchy top virus (BBTV) (Thomas and Dietzgen, 1991; Harding *et al.* 1991; 1993; Burns *et al.* 1993) and milk-vetch dwarf virus (MDV) (Isogai *et al.* 1992; Sano *et al.* 1993) and faba bean necrotic yellows virus (FBNYV) (Katul *et al.*, 1993).

- 5 In a particularly preferred embodiment, the circovirus contemplated for use in accordance with the present invention comprises more than two DNA components or segments.

10 The present invention is particularly directed and hereinafter described with reference to subterranean clover stunt virus (hereinafter abbreviated to "SCSV") as a representative of the circovirus group. This is done, however, with the understanding that reference to SCSV includes reference to all other suitable members of the circovirus group to which the instant invention extends. Preferred members of the circovirus group such as SCSV comprise more than two DNA components or segments. Reference hereinafter
15 to "SCSV" also includes and extends to all naturally occurring or artificially induced mutants, derivatives, parts, fragments, homologues or analogues of the virus which still retain at least one suitable promoter and/or termination and/or polyadenylation sequences.

- 20 Accordingly, a particularly preferred embodiment of the present invention contemplates a genetic construct comprising an SCSV promoter or promoter-like sequence and which is operable in a plant cell.

A related aspect of the present invention is directed to a genetic construct comprising
25 an SCSV promoter or promoter-like sequence and a termination and/or polyadenylation sequence, which sequences are operable in a plant cell.

The term "genetic construct" is used in its broadest sense to include any recombinant nucleic acid molecule such as an isolated nucleic acid molecule, vector, expression
30 vector or binary vector. It may comprise solely the circovirus promoter or may contain one or more promoters in association with regulatory and/or reporter sequences.

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- The genetic construct may be double or single stranded DNA, in linear or covalently closed circular form. As stated above, it may comprise only the promoter or promoter-like sequence or may carry other heterologous or homologous transcription regulator sequences and/or heterologous structural gene sequences including promoters associated
- 5 with SCSV. By "homologous" is meant a gene sequence naturally associated with the SCSV promoter. "Heterologous" means a "foreign" gene relative to the promoter or a gene not otherwise normally associated with the SCSV promoter. In a preferred embodiment, the foreign gene is also foreign to SCSV. Examples of foreign genes include genes which facilitate resistance to insects or other pest infestation, enhance
- 10 resistance to insecticides or herbicides, promote frost resistance, alter flower or petal colour, decrease the rate of senescence, especially in cut flowers, increase or enhance levels of certain proteins and/or ribozymes. More particularly, the foreign genes include:
- a) a resistance gene against plant viruses, bacteria, fungi, nematode and other pathogens;
 - 15 b) a plant virus resistance gene including a synthetic gene from and against alfalfa mosaic virus, subterranean clover stunt virus, subterranean clover mottle virus, subterranean clover red leaf virus, potato leafroll virus, tomato spotted wilt virus, bean yellow mosaic virus, white clover mosaic virus, clover yellow vein virus, potato viruses x, y, s, m and a, cucumber
 - 20 mosaic virus, rice ragged stunt virus and barley yellow dwarf virus;
 - c) a gene to improve nutritional value of plants such as sunflower high sulphur gene SF8;
 - d) a bloat resistance gene;
 - e) an antibody gene;
 - 25 f) a cereal thionin and ribosome inactivating protein gene;
 - g) an insect resistance gene including BT toxin gene and proteinase inhibitor gene from *Nicotiana glauca*;
 - h) a selectable marker gene such as those conferring resistance to kanamycin, phosphinothricin, spectinomycin and hygromycin;
 - 30 i) a reporter gene such as GUS, CAT and pigment genes;
 - j) a gene encoding a regulatory protein which modulates expression of a gene in plant cells.

- The present invention further contemplates a genetic construct comprising two heterologous genes operably linked to the same or different circovirus promoters operable in a plant cell. Preferably the promoter or different promoters are from a circovirus with a genome comprising more than two components or segments. Most preferably the promoter or different promoters are from SCSV and in particular are selected from segments 1 to 7 of SCSV as defined by SEQ ID NOs. 1 to 7. (See below). The genetic constructs may also comprise a termination or polyadenylation sequence operably linked to one or both of the heterologous genes. In one embodiment, the termination and/or polyadenylation sequence is the same for each gene. In an alternative embodiment the termination and/or polyadenylation sequence is different for each gene. Most preferably the termination and polyadenylation sequence is selected from segments 1 to 7 of SCSV as defined by SEQ ID NOs. 1 to 7 (See below). In yet another embodiment at least one termination and polyadenylation sequence is from the MeA 3 gene of *Flaveria bidentis* (see below).
- The term "transcription regulator" is used in its broadest sense to include promoters, termination and polyadenylation sequences and other effectors and facilitators of transcription of genetic sequences. As with promoters contemplated by the present invention, the termination and polyadenylation sequences may be of SCSV origin and may be naturally associated with a corresponding promoter from SCSV or may be associated with another promoter of SCSV. Alternatively, the termination and/or polyadenylation sequences may be derived from non-SCSV sources. A particularly preferred terminator comprises the 3' nucleotide sequence of the MeA3 gene of *Flaveria bidentis* which codes for an NADP-malic enzyme of C4 photosynthesis (Hatch, 1987).
- The nucleotide sequence of the terminator region of the MeA gene is shown in Figure 15. The combination of an SCSV promoter with, for example, the *F. bidentis* MeA gene terminator sequence results in a high level of expression especially in monocotyledonous plants relative to constructs without the terminator sequence.
- The foreign gene may also be in the antisense orientation so as to facilitate reduced levels of endogenous plant gene products. In this regard, "gene" may be ten base pairs in length, tens of base pairs in length, hundreds of base pairs in length or a full length

or near full length gene but in a reverse orientation relative the promoter. The foreign gene may also be placed in the "sense" orientation for co-suppression of a target gene.

According to another aspect of the present invention, there is provided a genetic
5 construct comprising an SCSV promoter or promoter-like sequence operable in a plant cell and at least one restriction endonuclease site downstream of said promoter to facilitate insertion of a heterologous gene such that said gene is operably linked to said promoter. In an alternative embodiment, the genetic construct comprises an SCSV
10 promoter or promoter-like sequence operable in a plant cell and a heterologous gene operably linked to said promoter. In both embodiments, the term "gene" includes those directing the synthesis of oligonucleotides such as those useful in antisense techniques as well as ribozymes.

In still a further embodiment of the present invention, there is contemplated a genetic
15 construct comprising an SCSV promoter or promoter-like sequence operable in a plant cell and at least one restriction endonuclease site downstream of said promoter to facilitate insertion of a heterologous gene such that said gene is operably linked to said promoter and a termination and/or polyadenylation sequence positioned such that same sequence is at the 3' end relative to said heterologous gene to facilitate expression of
20 said heterologous gene. Preferably, the termination sequence is from SCSV. Alternatively, the terminator sequence is from the *F. bidentis* MeA3 gene.

Plants contemplated by the present invention include both monocotyledonous and
25 dicotyledonous species. The present invention also extends to leguminous and non-leguminous plants although leguminous plants are preferred.

The SCSV genome comprises at least seven distinct circular ssDNA components described as segments 1-7. The size of these segments range from about 988 to about 1022 nucleotides. Each of the seven DNA components of SCSV contains one major
30 open reading frame of the viral sense and a non-coding region of various lengths containing a conserved potential stem and loop structure (Figures 1 and 2; Table 2). Each transcription unit contains a typical TATA box and a polyadenylation signal for

start and end of transcription, respectively (Figure 2, Table 2).

Because the DNAs are circular, the sequences in the non-coding regions comprise the promoters and the terminator signals which vary with different DNA components (Table 2). The TATA boxes and the stem-loops of the two replicase-associated protein genes in segments 2 and 6 are quite different from those of the other genes. In contrast, the stem-loops and TATA boxes are the same in segments 1, 3, 4, 5 and 7. All the DNAs, except those of segments 2 and 6, also share a common sequence (known as the common region) in the non-coding region (Figures 1 and 2).

The present invention, therefore, extends to each of the seven promoters and to termination and polyadenylation sequences on segments 1-7 of SCSV. The nucleotide sequences of segments 1-7 are shown in Figure 6 and are defined in SEQ ID NOs. 1-7, respectively.

Segment 5 was identified as the coat protein gene based on N-terminal amino acid sequence and amino acid composition data (Chu *et al.*, 1993a). Segments 2 and 6 encode proteins containing the characteristic NTP-binding motifs and thus are predicted to be the putative viral replication-associated protein (RAP) genes. The remaining 4 DNA components are unrelated to each other or to segment 2, 5 and 6, based on their distinctive deduced amino acid sequence. The SCSV DNAs have no significant nucleotide sequence homology with the genomes of geminiviruses although some homology exists at the deduced amino acid level.

The replicative competency of SCSV has been demonstrated (Chu *et al.*, 1993b). Since the SCSV virion DNA is single-stranded and the transcripts are of viral sense, the first likely biosynthetic event after uncoating is likely to be the synthesis of the replicative form DNA using host DNA polymerase. (The DNAs of SCSV have the ability to self prime in dsDNA synthesis [Chu and Helms, 1988]). Host RNA polymerase is thought to bind to the promoters initiating RNA transcription followed by synthesis of the viral proteins required for virus multiplication.

In a particularly preferred embodiment of the present invention, there is contemplated an SCSV promoter or promoter-like sequence comprising a nucleotide sequence selected from within SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3, SEQ ID NO: 4, SEQ ID NO: 5, SEQ ID NO: 6 and SEQ ID NO: 7 and/or genetic constructs comprising same.

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A "promoter-like sequence" as used herein includes any functional mutant, derivative, part, fragment, homologue or analogue of a naturally occurring SCSV promoter. Promoter-like sequences contemplated herein include single or multiple nucleotide substitutions, deletions and/or additions to an SCSV promoter, provided that the said promoter-like sequences retain at least 35%, preferably at least 45%, more preferably at least 55%, even more preferably at least 65-70% and still more preferably at least 85-95% or greater promoter activity compared with the corresponding wild-type SCSV promoter.

15 In yet another embodiment, there is provided a genetic construct comprising an SCSV promoter or promoter-like sequence and which is operable in a plant cell, said promoter or promoter-like sequence corresponding to all or part of any one of SEQ ID NO: 1 to 7 or capable of hybridising under a range of stringency conditions, ranging from high to low stringency conditions to at least one of SEQ ID NO: 1 to 7. Conveniently, a mutant, derivative, part, fragment, homologue or analogue of an SCSV promoter is defined as being functional in a plant cell and capable of hybridising under a range of at least high to low stringency conditions to at least one of SEQ ID NO: 1 to 7.

25 In a particularly preferred embodiment, the genetic construct further comprises a termination and/or polyadenylation sequence from SCSV or from non-SCSV source and which enhances or other facilitates expression of a gene operably linked to said promoter.

30 For the purposes of defining the level of stringency, reference can conveniently be made to Sambrook *et al* (1989) which is herein incorporated by reference where the washing steps at pages 9.52-9.57 are considered high stringency. A low stringency is defined herein as being in 0.1-0.5% w/v SDS at 37-45°C for 2-3 hours. Depending on the

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source and concentration of nucleic acid involved in the hybridisation, alternative conditions of stringency may be employed such as medium stringent conditions which are considered herein to be 0.25-0.5% w/v SDS at $\geq 45^{\circ}\text{C}$ for 2-3 hours or high stringent conditions as disclosed by Sambrook *et al* (1989).

5

Another embodiment of the present invention contemplates a method of expressing a foreign gene in a plant cell, said method comprising introducing into said plant cell a genetic construct comprising and SCSV promoter or promoter-like sequence operable in said plant cell and operably linked to said foreign gene. In a further embodiment, multiple SCSV promoters are used to drive one or more transgenes without antagonism. In yet a further embodiment, the SCSV promoter is associated with the SCSV segment 2 gene in order to enhance the expression of the foreign gene. In another embodiment, the genetic constructs further comprises one or more termination and/or polyadenylation sequences which are located at the 3' end of the foreign gene. These sequences enhance or otherwise facilitate expression of the foreign gene. The termination and/or polyadenylation segment may be from SCSV or from another source such as the *F. bidentis* MeA gene.

In still yet another embodiment, the present invention contemplates a transgenic plant carrying an SCSV promoter or promoter-like sequence as hereinbefore defined in its genome and optionally a termination and/or polyadenylation sequence to enhance expression of a gene downstream of said promoter. Preferably, the transgenic plant exhibits altered characteristics due to expression of a genetic sequence such as a gene, oligonucleotide or ribozyme downstream of the SCSV promoter.

25

The present invention is further described by reference to the following non-limiting figures and/or examples. Reference herein to a promoter region from SCSV is abbreviated to "S" for SCSV, the genome segment number (e.g. 1, 3, 4, 5 and 7) and "nc" for non-coding region. For example, the promoter from SCSV genome segment 1 is defined as "S1nc". Terminator sequences for particular SCSV genome segments are indicated for example, as follows: "SC1Tr" or "SC5Tr" for the terminator sequences for segments 1 and 5, respectively. Genetic constructs comprising an SCSV promoter, a

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reporter gene such as *GUS* and a terminator sequence such as from SCSV is abbreviated to "SCSV:*GUS*:SCTr" or "SCSV:*GUS*:SCSVTr". Specific promoters and termination sequences are defined as above, for example S4nc:*GUS*:SC1Tr or S4nc:*GUS*:Me3", "S4nc:*GUS*:Me3". In the latter construct the terminator sequence from the MeA gene
5 of *Flaveria bidentis* is used, referred to herein as "Me3".

In the Figures:

FIGURE 1 shows the structures and transcription units found in a representative DNA
10 component of a typical geminivirus and SCSV, both of which contain a ssDNA genome.

FIGURE 2 shows the seven DNA segments found in the genome of SCSV in a linear form, indicating the positions of the stem-loop structure, the common region, the open reading frame (ORF), the TATA box and the termination and polyadenylation signals
15 on each DNA.

FIGURE 3 shows the construction of the seven SCSV DNA non-coding region: β -glucuronidase (*GUS*) fusion expression vectors for transformation into tobacco plants. The amplified PCR fragments were separately cloned in front of the *GUS* gene in pHW9
20 at the BamHI (B) and *Nco*I (N) sites as indicated. The resultant recombinant pHW9 vectors were cut at the *Eco*RI site and cloned into the *Eco*RI site of the recipient PGA470 binary vector.

FIGURE 4 shows the construction of the segments 5 and 7 promoter:*GUS* fusion
25 expression vectors and their deletion derivatives for protoplast studies. DNAs corresponding to the full-length non-coding regions were obtained by PCR and cloned into pKGO in front of *GUS* by blunt end ligation at the *Sa*I site as indicated. The deletion derivatives were obtained by digesting the pKGO clones containing the full-length sequence with HindIII or PstI on the vector and the appropriate restriction
30 enzymes on the SCSV sequence as indicated. The deleted pKGO constructs were religated after end-filling as required.

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FIGURE 5 shows the construction of the recombinant binary pTAB10 vector (pBS150) containing the seg 7 promoter(57nc):*GUS* fusion gene for transformation into subterranean clover plants. The 57nc:*GUS* expression cassette was excised from the pKGO construct (Fig. 4) by digestion with *Hind*III and *Bam*HI and blunt-end ligated to pTAB10 at the *Eco*RI site after end-filling the DNAs.

FIGURE 6 shows the complete sequences of the seven SCSV DNA circles. The sequence of the non-coding region on each DNA used in the construction of the expression cassettes are underlined.

FIGURE 7 shows GUS expression detected by histochemical staining on leaves of transgenic tobacco and subterranean clover transformed with the SCSV seg 7 promoter(57nc):*GUS* fusion expression cassette.

FIGURES 8A to 8F are photographic representations of histochemical staining for GUS activity in transgenic plants - bright field. Bright field exposures of stained leaf pieces (L), stem sections (S), roots (R) and pollen (P) from tobacco plants transformed with the GUS fusion constructs containing the SCSV promoter regions from segments 1, 3, 4, 5 and 7 referred to as S1nc, S3nc, S4nc, S5nc and S7nc promoter regions and from non-transformed plants (NT). Blue colouration indicates GUS expression. Each leaf, stem or root piece represents an independent transformant (except the top two root pieces of S5nc which could not be separated easily) and the pollen samples were mixtures from two or more transformants. Fig. 8a shows differential expression of GUS in plants transformed with either S4nc or S5nc regions compared to a non-transformed plant (NT).

FIGURES 9A to 9E are photographic representations showing histochemical staining for GUS activity in transgenic plants - dark field. Transverse (T) and longitudinal(L) thin sections of stained, embedded stem pieces from tobacco plants transformed with the GUS fusion constructs containing the component 1 (S1nc), 3 (S3nc), 4 (S4nc), 5 (S5nc), and 7 (S7nc) promoter regions, viewed with a dark field. Pink crystals indicate GUS expression. The stem pieces used for the transverse and longitudinal sections represent

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independent transformants. The magnifications are: 375X in S1nc T and L, S3nc L, S4nc T, S5nc T and L, and S7nc L; 480X in S3nc T; 200X in S4nc L; and 300X in S7nc T.

- 5 **FIGURE 10** is a graphical representation of a fluorometric assay for GUS expression. Fluorometric assay results from leaf extracts of tobacco plants transformed with the GUS fusion constructs containing the component 1 (S1nc), 3 (S3nc), 4, (S4nc), 5 (S5nc), and 7 (S7nc) promoter regions. Each column represents an independent transformant. GUS activities were measured with a Labsystems Fluoroskan at 5 or 10 minute intervals over
- 10 60 minutes (or 30 minutes for S4nc) using 4-methylumbelliferyl β -D-glucuronide (MUG) as the substrate. The rates of GUS activity are expressed as fluorometric units (Fl.U.) per minute per mg of protein. 1000 Fl.U is approximately equal to 825 pmoles of 4-methylumbelliferone (MU).
- 15 **FIGURE 11** is a diagrammatic representation of the SCSV segment 2 promoter (S2nc) construct capable of directing GUS expression in tobacco protoplasts. A fragment of segment 2 DNA from *NcoI-XbaI* was fused to the promoterless GUS vector, pKGO. Pr, promoter, seg 2, segment 2 of SCSV.
- 20 **FIGURES 12a and 12b** are diagrammatic representations showing constructs of SCSV:GUS:SCSV Tr expression vectors. The termination/polyadenylation sequences for segment 3 of SCSV (SC3Tr) and segment 5 (SC5Tr) were amplified by PCR and cut with the respective restriction enzymes and then cloned into recombinant pKGO vector as indicated. The SC3Tr construct was cloned as an *EcoRI-XhoI* fragment into
- 25 the pKGo vector containing S1nc:GUS:OCS3' to make S1nc:GUS:SC3Tr. The SSC5TR construct was made as an *EcoRV* fragment into Vector pKGO containing S4nc:Gus:OCS3' to make S4nc:GUS:S5Tr.
- FIGURES 13A to 13D** are photographic representations showing GUS expression in
- 30 potato plant tissues directed by the SCSV segment 4 promoter (S4nc). A. stem; B. leaf; C. stolon; and D. tuber.

FIGURE 14 is a photographic representation of GUS expression in cotton leaf directed by the SCSV segment 7 promoter (S7nc).

FIGURE 15 is a representation of the MeA3's terminator sequence of the *Flaveria bidentis* MeA gene (Me3). The stop codon is shown in bold face type at the beginning of the sequence. This sequence was engineered in the Chimeric construct to include an *Eco*R1 site: GAATTCGTTTAG.... The chimeric constructs thus contained a sequence beginning AATTCGTTTAG.

FIGURE 16 is a diagrammatic representation of GUS expression vectors (ME20 and ME29) containing the indicated *Flaveria bidentis* MeA gene regulatory elements.

FIGURE 17 is a diagrammatic representation of the construction of S4nc plasmid pBS237 containing the expression cassette S4nc:*GUS*:Me3'. Plasmid pBS218 was digested with *Eco*R1 to remove OCS3' region and ligated with an *Eco*R1.

FIGURE 18 is a diagrammatic representation of the construction of plasmid pBS246 containing the S1nc:nptII:SC3Tr expression cassette. The *Sal*I-*Sal*I fragment is approximately 8.5-9 kbp; B_L is about 0.5 kbp; B_R is about 0.6 kbp. SC1nc:nptII:SC3Tr is about 1.7 kbp.

FIGURE 19a-c are diagrammatic representations of the construction of plasmid pKHAN4 from pKHAN2 and pKSB.bar1. pKHAN4: A *Hind*III-*Eco*R1 segment containing S7nc (572 bp), nptII coding region (978 bp) and vicillin 3' end (276bp) from pKHAN2 was inserted into binary plasmid pKSB.bar1 to yield pKHAN4; pKHAN2. The nptII coding region (978bp, *Bam*HI-*Sma*I fragment) from p35SKN was cloned into Asp718 site (blunted with klenow fragment) of pKHAN1 to create pKHAN 2. SCSV Pro = S7nc; pKSB. Bar 1: pTAB10.MCSori1B digested with *Eco*R1 as ligated together.

FIGURE 20 is a photographic representation of a selection of Kanamycin resistant tobacco plants on regeneration medium transformed with binary vectors containing either 35S promoter:NPTII:35S terminator sequence (35SPrm:NPTII:35STrm) or

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S1nc:NPTII:SC3Tr expression cassette. (In the Figures, the abbreviations are 35S Prm NPTII35STrm and SC1 Prm NPTII Sc3 Trm, respectively.

FIGURE 21 is a diagrammatic representation of a cloning vector utilising SCSV DNA
5 transcription regulatory signals.

FIGURE 22 is a diagrammatic representation of SCSV segment 2 dimer construct pBS2. This construct was created by cloning a tandem repeat of the SCSV segment 2 DNA (containing a whole functional seg 2 transcription unit) into the polylinker site of
10 pGEM7 which was then cloned into a reduced version of the pMCP3 binary vector (Khan *et al.*, 1994).

A summary of the transcription activities facilitated by the SCSV transcription regulatory elements is shown in Table 19.

15

EXAMPLE 1

SCSV DNA sequence determination

The F isolate of SCSV (Chu *et al.* 1993a) was used for sequence determination. Full-length clones of the SCSV genome components were created from the replicative
20 form (RF) DNA as described by Chu *et al.* (1993a). Other clones were created from the RF by PCR with SCSV specific primers designed from known sequences.

The dideoxy chain termination method (Sanger *et al.*, 1977) was used to sequence either M13 ssDNA templates (Sambrook *et al.*, 1989) or dsDNA templates prepared by the
25 CTAB method (Del Sal *et al.*, 1989) from clones described above. Sequence analysis was carried out using the University of Wisconsin Genetics Computer Group Sequence Analysis Software Package (Devereaux *et al.*, 1984).

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EXAMPLE 2**Plasmid construction**

DNA manipulation techniques used were as described by Sambrook et al. (1989). The entire non-coding regions of all 7 DNA segments of SCSV were amplified by PCR using specific primers (See Table 8) with appropriate restriction enzyme recognition sites for cloning into the plasmid vectors. The amplified DNA fragments were separately cloned into the respective expression vectors upstream of a promoterless GUS reporter gene in the appropriate orientation to produce the SCSV promoter-GUS fusion constructs as shown in the Figures 3 and 4. The expression vector pHW9 (Fig. 3) followed by cloning into the binary vector pGA470 (An et al., 1985) were used for tobacco transformation. The expression vector pKGO was used for GUS expression in protoplasts (Fig. 4) and the binary vector pTAB10 was used for subterranean clover transformation (Fig. 5). pKGO was constructed by cloning the *XhoI* fragment of pKIWI101 (Janssen and Gardner, 1989) containing the GUS gene and the OCS terminator sequence into the *SalI* site of pKKm (Kirschman and Cramer, 1988). Corresponding plasmids containing the 35S promoter fused to GUS were used as controls. The junctions of the clones were checked by sequencing. A promoterless GUS construct was used as a control.

Deletion derivatives of the SCSV segments 5 and 7 promoters were made by digesting the full-length non-coding sequence with an appropriate enzyme to produce the desired deletion (Fig. 4).

To investigate the phenomenon of transactivation, the *S5nc:GUS* expression cassette was excised from recombinant pKGO constructs and cloned into a pGEM plasmid containing the seg 2 RAP coding region expressed from the 35S promoter. The resultant plasmid carrying both the SCSV promoter:*GUS* and the 35S promoter:seg 2 RAP expression cassettes were electroporated into protoplasts.

EXAMPLE 3**Protoplast isolation and transient gene expression**

Recombinant plasmids were extracted from *E. coli* by alkaline lysis followed by
5 purification through Qiagen columns as described in the Qiagen Plasmid Handbook.

Suspension cell cultures were used to isolate *Nicotiana plumbaginifolia* (Last *et al.*
1991) and subterranean clover cv. Woogenellup protoplasts (Chu *et al.* 1993b). Purified
plasmids were electroporated into protoplasts of subterranean clover or *Nicotiana*
10 *plumbaginifolia* as described by Taylor and Larkin (1988). Protoplasts were harvested
3 days later and assayed fluorometrically for transient GUS activity using 4-methyl
umbelliferyl β -glucuronide as substrate (see below). All experiments were done using
duplicate samples per treatment.

15

EXAMPLE 4**Transformation of tobacco with SCSV-promoter-GUS fusion constructs**

The recombinant pGA470 binary constructs containing the various SCSV promoter:*GUS*
expression cassettes were separately transformed into *Agrobacterium tumefaciens* strain
LBA4404 (Hoekema *et al.* 1983) by electroporation as described by Nagel *et al.* (1990).
20 *Nicotiana tabacum* cv. Wisconsin 38 were transformed and regenerated as described by
Ellis *et al.* (1987).

EXAMPLE 5**Transformation of subterranean clover with SCSV-promoter-GUS fusion construct**

25 The recombinant pTAB10 binary vector containing the S7nc:*GUS* fusion construct
(pBS150) was transformed into *Agrobacterium tumefaciens* strain AGL1 (Lazo *et al.*
1991) by triparental mating (Ditta *et al.* 1980). Subterranean clover cv. Larisa was
transformed by *Agrobacterium*-mediated transformation and regenerated as described by
Khan *et al.* (1994).

30

EXAMPLE 6**GUS assays**

Protoplasts were lysed by sonication in the presence of 0.3% v/v Triton X-100 immediately after harvest. GUS activity of the soluble extract was determined in a fluorometric assay using the substrate 4-methyl umbelliferyl β -D-glucuronide (MUG) (Jefferson *et al.*, 1987). Fluorescence was measured using a Labsystem Fluoroskan II spectrophotometer.

- 10 GUS expression in intact transgenic tissues was detected by histochemical staining in 5-bromo-4-chloro-3-indolyl- β -glucuronic acid (X-gluc) (Jefferson *et al.*, 1987) and by fluorometric assay of the soluble extract using MUG.

EXAMPLE 7**Sequence of SCSV non-coding region**

- 15 The complete sequences of all the 7 known SCSV DNA circles have been determined (Fig. 6). Each DNA contains a non-coding region with signals (TATA boxes) for promoter activity (Table 2). These sequences have not been described or isolated before. Sequence comparison of the non-coding regions comprising these promoters showed that
20 segments 3 and 5 are most similar, sharing 258 conserved nucleotides out of an average of 491 nucleotides in the non-coding regions of the DNAs. Segments 3, 4, 5 and 7 contain 170 conserved bases between them while only 152 bases are conserved between Segments 1, 3, 4, 5 and 7. The sequence variations in the non-coding regions of the SCSV DNAs suggest that the transcription and replication of the different SCSV genes
25 may be regulated differently.

EXAMPLE 8**Transient activity of SCSV promoters in protoplasts**

- The promoter activities of two SCSV DNA non-coding regions have been demonstrated
30 directly by transient expression of GUS using SCSV promoter:GUS fusion constructs in subterranean clover (Table 3) and tobacco protoplasts (Table 4). These results showed that both segment 5 and segment 7 promoters are functional in the absence of other

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SCSV DNA components. The SCSV promoters are also functional in protoplasts of either a natural host (subterranean clover) or a non host (tobacco). In tobacco protoplasts, the segment 7 promoter was similar in activity to the 35S promoter while the segment 5 (coat protein) promoter consistently showed activity about half that of the CaMV 35S promoter (Table 4). However, the activity of both promoters were higher in subterranean clover protoplasts, with the activity of the segment 7 promoter showing up to several times that of the 35S promoter (Table 3), suggesting that SCSV promoters work better in certain legumes than the widely used 35S promoter. The activity of the segment 7 promoter also appeared to be more variable in subterranean clover protoplasts than the others tested.

Plasmids containing various deletion derivatives of the non-coding sequence of segments 5 and 7 fused to GUS were also constructed (Fig. 4) and electroporated into protoplasts (Table 5). GUS assays of protoplasts transfected with these constructs showed that neither the stem-loop nor the common region were necessary for promoter activity although the latter was required for full activity (Table 5). The DNA sequence required for high level promoter activity appears to be less than 300 bp which is smaller than that required for other promoters, such as 35S promoter (Odell *et al.*, 1985).

20

EXAMPLE 9

Transactivation of SCSV promoter activity by SCSV segment 2 gene product
When co-electroporated with a 35S promoter:seg 2 RAP gene construct, the activities of GUS driven by the seg 5 promoter apparently increased by about 2 fold in both subterranean clover and tobacco protoplasts (Table 6). The segment 7 promoter activity may also be increased when co-electroporated with the 35S:seg 2 RAP construct but further experiments are needed to confirm this.

Transactivation of GUS activity was also apparently observed when the S5nc:GUS construct was co-electroporated with a binary vector plasmid (pBS2) containing a tandem repeat (dimer) of the segment 2 DNA (Table 6). A map of SCSV segment 2 dimer construct -pBS2 is shown in Figure 22. This construct was created by cloning a tandem repeat of the SCSV segment 2 DNA (containing a whole functional seg 2

transcription unit) into the polylinker site of pGEM7 which was then cloned into a reduced version of the pMCP3 binary vector (Khan *et al.*, 1994). The results suggest that both SCSV promoters are expressed concurrently. Thus, different SCSV promoters can either be used in combination with a 35S promoter or be used simultaneously to facilitate concurrent expression of multiple transgenes in plants. In contrast, reduced transgene activity has been observed when the 35S promoter is used in multiple or multiple copy transgenes (Linn *et al.*, 1990; Matzke and Matzke, 1991; Scheid *et al.*, 1991; Carvalho *et al.*, 1992).

10

EXAMPLE 10

Activity of SCSV promoters in transgenic plants

All the SCSV promoters, except those from segments 2 and 6, have been shown to be capable of driving expression of transgenes in tobacco plants (Fig. 7). The level of activity of the promoters measured by the MUG assay varied from plant to plant and from one promoter to another but is generally lower than that of the 35S promoter (Table 7).

Histochemical staining of intact transgenic tobacco tissues showed that the activity of the S4nc promoter appears to be constitutive and GUS activity was detected in all plant organs. The others are generally restricted to the vascular tissues although expression is also detected in pollen.

In transgenic subterranean clover plants expressing the S7nc:*GUS* gene construct, histochemical staining showed that GUS activity is found in leaves, stems and petioles. The distribution of GUS activity is mostly constitutive although in some tissues, the activity is largely in vascular tissues (Figure 7). In these plants, the level of promoter activity also varies from plant to plant but the activity is generally comparable to that of the 35S promoter.

These results indicate that the SCSV promoters provide a choice of promoters that can be used either independently or simultaneously to control the expression of one or more foreign genes in a wide range of plants and tissue types. Legumes are a major target

for application. The activity of these promoters also can be enhanced by the presence of the seg 2 gene product. Thus, these promoters appear to have significant advantages over the CaMV 35S promoter, both in levels of expression, size and in overcoming some negative features of the 35S promoter. They would be applicable in a wide range of transgenic applications.

TABLE I

Properties of plant viruses with small and multiple encapsidated circular ssDNAs
(Plant Circoviruses)

10	Virus	Hosts	Vector	No. of circles	Size (kb)	Coat protein (kDa)
15	FBNYV	Legumes	Aphids	2+	1	22
	MDV	Legumes	Aphids	1+	1	21
	SCSV	Legumes	Aphids	7	1	19
20	BBTV	Monocots	Aphids	6+	1-1.2	20
	CFDV	Monocots	Planthopper	1+	1.3	25

Compiled from data presented at the Sixth International Congress of Plant Pathology,
25 Montreal, July, 1993. FBNYV = faba bean necrotic yellow virus, MDV = milk vetch
dwarf virus, SCSV = subterranean clover stunt virus, BBTV = banana bunchy top virus,
CFDV = coconut foliar decay virus.

TABLE 2
Transcription units and putative gene functions of the SCSV DNA segments

DNA Segment	Segment (bases)	Non-Coding Region		TATA Box		ORF		Termination Codon	Polyadenylation Signal
		Function	Region (bases)	Pos ^a	Sequence	Pos ^b	# aa		
1	1001	Unknown	661	201	TATAAAT	48	112	12.7	TGA
2	1022	Replication	178	-8	TATATAT	102	280	32.5	TGA
3	991	Unknown	495	326	TATAAAT	57	164	19.1	TGA
4	1002	Unknown	539	285	TATAAAT	71	153	17.7	TAA
5	998	Coat protein	487	330	TATAAAT	48	169	18.7	TAA
6	1017	Replication	158	-7	AATATAA	66	285	33.5	TGA
7	988	Unknown	546	324	TATAAAT	67	146	16.9	TAA

^a Position of the TATA box is the number of bases from the first nucleotide of the stem-loop to and including the first base of the TATA box. See Fig. 1 for a graphic presentation of the genome segments.

^b Position of the ORF is the number of bases from the first base of the TATA box to and including the first base of the initiation codon.

TABLE 3
SCSV promoter directed GUS activity in subterranean clover protoplasts

5						
10	Treatments	GUS Activities				
		Expt 1		Expt 2		Average
		Act	%35S	Act	%35S	%35S
15						
	No DNA	10	0%	13.1	0%	0%
	35S: <i>GUS</i>	27.3	100%	36.6	100%	100%
	S5nc: <i>GUS</i>	22.6	73%	40.2	116%	95%
20	S7nc: <i>GUS</i>	36	147%	117	385%	266%

All experiments were done using duplicate samples per treatment. GUS activity was measured using a Labsystem Fluoroskan II spectrophotometer and is presented both in absolute activity (Act) and as a percentage of 35S:*GUS* activity (%35S).

25 ' constructs are represented as "promoter:reporter gene". For example, "35S:*GUS*" is the 35S promoter and the GUS reporter gene. "S5nc" and "S7nc" are the promoters for segments 5 and 7, respectively of SCSV.

TABLE 4
SCSV promoter directed GUS activity in tobacco protoplasts

10	Treatments	GUS Activities				
		Expt 1		Expt 2		Average
		Act	%35S	Act	%35S	%35S
15	No DNA	13.8	0%	10.5	0%	0%
	35S: <i>GUS</i>	113	100%	117	100%	100%
	S5nc: <i>GUS</i>	52.3	39%	61	48%	44%
	S7nc: <i>GUS</i>	93	80%	106	90%	85%
20						

All experiments were done using duplicate samples per treatment. GUS activity was measured using a Labsystem Fluoroskan II spectrophotometer and is presented both in absolute activity (Act) and as a percentage of 35S:*GUS* activity (%35S).

TABLE 5

Promoter activities (GUS expression levels) of deletion derivatives
of segment 5 and 7 non-coding regions in protoplasts.

5 Levels are expressed as percentages of the activity of the respective
full-length non-coding sequence.

		GUS Activity				
		Tobacco		Subclover		
10	Promoter	Deletion ^a	Expt 1	Expt 2	Expt 1	Expt 2
20	Segment 5	dNde	101	110	-	-
		dPml (stem-loop)	65	88	-	-
		dAfl (Stem-loop+ common region)	70	102	63	91
		dPst	5	18	6	4
25	Segment 7	dAfl (stem-loop+ common region)	50	55	67	39

^a See Figure 4 for maps of deletion derivatives.

30

TABLE 6

Transactivation of segment 5 promoter activity (GUS expression)
in tobacco and subterranean clover protoplasts by gene product of segment 2.

5	GUS Activity ^a					
	Promoter Construct	Protoplasts	Expt 1	Expt 2	Expt 3	Expt 4
10	S5nc: <i>GUS</i>	Tobacco	100	100	-	-
	15 S5nc: <i>GUS</i> + 35S:Seg 2 RAP	Tobacco	262	217	-	-
20	S5nc: <i>GUS</i>	Subclover	100	100	100	100
	S5nc: <i>GUS</i> + 35S:Seg 2 RAP	Subclover	132	176	188	770
	S5nc: <i>GUS</i> + Seg 2 dimer ^b	Subclover	-	-	-	320

25

^a GUS activities are expressed as percentages of the S5nc:*GUS* construct in each experiment

^b See Example 9

TABLE 7

Relative GUS activity in leaf extracts of independent transgenic tobacco plants containing different promoter:*GUS* constructs as determined by fluorometric assays^a

5			
10	Promoter	GUS Activity	Average
	Non transgenic control	123	
	Average		123
15	35S #3	38,431	
	#6	20,052	
	#8	20,648	
	#11	28,325	
	#12	24,700	
	Average		26,431
20	S4nc #1	7,229	
	#2	4,690	
	#5B	4,300	
	#9	6,218	
	#18	4,895	
25	#19	6,098	
	Average		5,572
	S7nc #4	642	
	Average		642
30			

^a GUS activity presented is the best 25% of the transgenic plants tested.

EXAMPLE 11**Further characterisation of SCSV promoter activities in transgenic plants**

- 5 Transgenic plants of tobacco transformed with the five (Segments 1, 3, 4, 5 and 7) SCSV promoter:*GUS* fusion cassettes were assayed for GUS activity by both histochemical (Figs. 8 and 9) and fluorometric assays (Fig. 10). Samples taken from tissue-cultured and young glasshouse-grown plants produced the same GUS expression pattern. GUS activity was observed in all plant parts, including roots, stems, leaves, petioles and all flower parts. Promoter 5 construct gave relative lower GUS expression in pollen than other promoters. The results from fluorometric assays confirmed previous data showing that segment 4 promoter was the highest expressor, with activity 10-fold or greater than the rest (Fig. 10), but is still lower than that of the 35S promoter. The expression levels of the segment 1, 3, 5 and 7 promoters were comparable to those of the phloem-specific promoter *rolC* in tobacco (Schmulling *et al.*, 1989; Sugaya *et al.*, 1989). Plants transformed with the promoterless GUS construct did not express GUS by either assay method. Histochemical assays showed that expression of all promoter constructs was the highest in vascular tissues, with high expressors being more constitutive than low expressors which are more vascular-limited (Fig. 8). In general, promoter 1, 3, 5 and 7 constructs are expressed mostly in the vascular tissues. In particular, GUS expression by promoter 1 and 3 constructs are mainly restricted to phloem tissues. However, for all promoters histochemical staining of leaves showed that GUS expression in these tissues are often blotchy (constitutive and vascular-limited) and variable between leaves of the same plant. Dark field microscopy (Jacobsen-Lyon *et al.*, 1995) also showed that none are strictly vascular-limited (Fig. 9).

- Twenty primary transgenic subterranean clover plants expressing the seg 7 promoter:*GUS* gene were further characterised by histochemical assays (Table 9). These assays showed that GUS activity was observed in all plant parts, including roots, stems, leaves and petioles. GUS expression was the highest in vascular tissues, with some leaves being more constitutive and blotchy than other organs and high GUS

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expressing plants being more constitutive than low expressing ones. Samples taken from tissue-cultured and glasshouse-grown plants produced the same GUS expression pattern.

5

EXAMPLE 12**Detection of promoter activity in SCSV segment 2 DNA**

Experiments showed that the non-coding regions from the SCSV segments 2 and 6 DNAs were unable to drive the expression of GUS gene in transgenic tobacco. These regions are only 179 and 159 nucleotides long, respectively, and it is likely that additional sequences are required for promoter activity. To test this hypothesis, a new segment 2 promoter sequence was constructed consisting of the DNA fragment from nucleotides 526 to 46 and fused to the promoterless GUS vector pKGO (Fig. 11). The fusion construct was electroporated into tobacco protoplasts. Gus activity was detected in electroporated tobacco protoplasts at levels similar to that of segment 5 promoter:*GUS* construct (Table 10).

A binary vector containing the above SRnc promoter:*GUS* fusion DNA was also transformed into tobacco plants as described in Example 4. Histochemical staining of several transformed tobacco plants showed that GUS expression was mainly vascular. These results showed that additional sequence from the SCSV segment 2 DNA coding region is necessary for promoter function. Since the SCSV segment 6 is a variant of the segment 2, it is expected that a similar construct comprising the noncoding and part of the coding region of this DNA will produce an active promoter. Thus, all SCSV promoters are expected to be suitable for driving gene expression in plants.

EXAMPLE 13**Enhancement of gene expression by SCSV transcription termination and polyadenylation signals**

5

Effective gene expression requires not only a promoter, but also specific nucleotide sequences at the 3' end of the coding region of the gene, known as the termination and polyadenylation signals (Messing *et al.*, 1983; Joshi 1987b; Gil and Proudfoot, 1984; Rothnie *et al.*, 1994). These special sequences are required to signal the RNA polymerase to stop transcription and to allow further processing of the RNA transcript. The activity of the termination and polyadenylation signals may affect the transcription efficiency and stability of the RNA being transcribed. Some widely used termination/polyadenylation sequences include those from the NOS (Depicker *et al.*, 1982), OCS (Janssen and Gardner, 1989) and CaMV 35S (Pietrzak *et al.*, 1986) genes.

15

Each of the SCSV DNA segment (or component) contained a terminator sequence comprising a termination and a polyadenylation signal sequence in the noncoding region (Table 11; Figure 2). To demonstrate activity of the termination/polyadenylation signals in SCSV DNA, GUS expression vectors containing either the segment 3 or segment 5 polyadenylation and termination signal (Fig. 12) was constructed and subjected to transient expression in tobacco protoplasts. The respective terminator sequence was amplified by PCR with several restriction sites incorporated into the primers (Fig. 12). The amplified terminator fragments were cut with the indicated restriction enzymes and cloned into the pKGO recombinant plasmid containing either S1nc or S4nc promoter:*GUS*:OCS3' constructs, from which the OCS3' sequence has been deleted (Fig. 12). The resultant S1nc:*GUS*:SC3Tr (the segment 1 promoter here carries a deletion of the *Hind*III fragment from nucleotides 641-782 which has no effect on GUS activity) and S4nc:*GUS*:S5Tr constructs were electroporated into tobacco protoplasts and assayed for GUS activity. The results showed that GUS activity was increased 2 to 3-fold when the SCSV termination/polyadenylation sequence was used instead of the commonly used OCS termination/polyadenylation sequence in the same construct (Table 12). In the same

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- 30 -

experiment, the construct S1nc:*GUS*:S3Tr produced over two-fold higher activity than the 35S:*GUS*:OCS3' construct (Table 12). These results indicate that each of the SCSV DNA components contains a different termination and polyadenylation signal sequence which can be used in various combination with the SCSV promoters to regulate and/or enhance expression of foreign genes in plants. As with the SCSV promoter sequences, the SCSV termination/polyadenylation sequences are advantageous over currently available termination/polyadenylation sequences by their small sizes (160-170 nucleotides) and the availability of a broad range of transcription regulators with different strengths and tissue specificities for genetic manipulation. The results also show that the use of a SCSV promoter in combination with a SCSV terminator sequence in higher levels of gene expression than constructs using the 35S promoter in conjunction with one of the common transcription terminator sequences.

EXAMPLE 14

Activity of SCSV promoters in transgenic potato plants

pGA470 binary vector containing the S4nc:*GUS*:NOS fusion construct cloned in pHW9 (Figure 3) was used to transform potato plants. pHW9 is derived from pHW8 (Dolferus *et al.*, 1994) into which the polylinker from pGEM3zf(+) is inserted. The recombinant binary vector was transformed into *Agrobacterium tumefaciens* strain LBA4404 by electroporation (Nagel *et al.*, 1990). Potato cultivars Atlantic and Sebago were transformed and regenerated essentially as described by Wenzler *et al.* (1989) except for the following modifications. Stem pieces instead of leaf pieces were used for transformation and 10 mg/l of benzylaminopurine (BAP) instead of 2.24 mg/l was used during co-cultivation. After co-cultivation, stage I medium is supplemented with 100mg/l of cefotaxime and not kanamycin or carbenicillin. Stage II medium contained 2 mg/l BAP, 5 mg/l GA3, 100 mg/l kanamycin and 100 mg/l cefotaxime.

Six transformed plants comprising 5 of cultivar Atlantic and 1 of cultivar Sebago were transferred and grown in the glasshouse for 10-11 weeks until small tubers formed. Tissues from different parts of the plants were assayed by histochemical GUS staining. The results showed that GUS was highly expressed in all plant parts including roots,

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stolons, tubers, stems and leaves but the expression was predominantly vascular, including cambium, phloem elements and some xylem elements (Fig. 13). As in other transgenic hosts, GUS expression in non-vascular tissues of highly GUS active plant materials, especially young tubers, was more evident than in less active tissues when compared with plants transformed with a 35S:*GUS*:NOS construct, SCSV promoter directed *GUS* expression in tubers was at least as high as that of the 35S:*GUS* construct.

EXAMPLE 15

Activity of SCSV segment 7 promoter in transgenic cotton plants

pGA470 binary vector containing S7nc:*GUS*:NOS fusion construct cloned in pHW9 was used to transform cotton plants. The recombinant binary vector was transformed into *Agrobacterium tumefaciens* strain AGL1 by triparental mating. Cotton (*Gossypium hirsutum*) cv. coker 315 was transformed and regenerated as described by Cousins *et al.* (1991).

Transformed plants were grown in the glasshouse and leaf tissues from 18 independent transgenic plants were assayed for GUS activity by histochemical staining. GUS activity varied between plants. Five of these plants showed strong GUS expression, similar in range to 35S promoter driven GUS expression and was predominantly in the vascular tissues (Fig. 14). GUS activity was especially strong in the gossypol glands. As in other transgenic hosts, GUS staining in highly expressed tissues were also constitutive.

A variety of tissues from these plants were then stained and vascular expression was observed in all organs including roots, stems, petioles, petals and other vascularised floral parts. Expression appears to be particularly high in young flower buds. Seedlings from one of the lines was screened for GUS activity. All 10 progenies stained heavily in roots and leaves indicating that the gene was inherited and that the line probably contained more than one independent insertion site.

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EXAMPLE 16**Stability of transformed SCSV promoter:*GUS* expression cassette in transgenic plants**

- 5 The stability of *GUS* expression driven by the various SCSV promoters in transgenic tobacco and subclover were further characterised in T1 generation seedlings of subterranean clover and tobacco plants.

10 In tobacco, T1 seedlings from 10 independent transgenic lines were assayed by histochemical staining. The results showed that the expression of the *GUS* gene driven by all the five (segments 1,3,4,5 and 7) promoters was stable in the T1 seedlings, with the pattern of expression being maintained in all cases between T0 and T1 plant tissues of the same age. In very young stems where the vascular tissues are not well differentiated, expression from all promoters were very high and was detected
15 through out the stem tissues. Gradual vascular limitation occurs with age and with increasing differentiation of the vascular bundles. As with T0 plants, the segment 4 promoter mediated *GUS* expression was more constitutive than others.

20 Fifty 2-3 month old T1 seedlings from 15 independent transgenic subclover plants expressing the S7nc:*GUS* fusion construct were assayed for *GUS* activity by histochemical and fluorometric assays. The results showed that the expression of the *GUS* gene driven by the segment 7 promoter was stable in T1 seedlings, with the pattern of expression being maintained between T0 and T1 plant tissues of the same age. *GUS* expression was found to generally segregate at the expected ratio of 3:1.
25 The preliminary results from fluorometric assays confirmed the histochemical data suggesting that this segment 7 promoter construct had *GUS* activity somewhat lower than that of the 35S promoter in leaves and petioles (Table 13). *GUS* activity in subterranean clover stems, however, was 3-fold higher than in petioles and 6-fold higher than in leaves (Table 14). The age of the plants at the time of assay was 2 to 3
30 months.

EXAMPLE 17**Transient activity of SCSV promoter in soybean leaves**

5 The SCSV promoter:*GUS* construct used (Table 15) was derived from the promoterless *GUS* plasmid pKGO (Figure 4; pJKKmf(-) K1W1 *GUS*:OCS) described previously while the 35S promoter:*GUS* construct was pGUS. pGUS is derived by cloning the *Gus* gene from pKIWI101 into the plant expression vector pDH51 (Pietrzak *et al.*, 1986).

10

For transient *GUS* expression in soybean tissues, the *GUS* constructs were introduced into tissues by particle bombardment using the Bio-Rad Biolistic PDS-1000/He Particle Delivery System as above. A 50 μ l suspension containing 3mg of a 1:1 ratio of 1 and 5 μ gold particles plus 6 μ g of DNA was shot onto plates containing 3 leaves
15 each. Fully expanded leaves used in these experiments were prepared from 24 day old soybean plants cv. Wayne. After particle bombardment, *GUS* activity was assayed 24 hours later by vacuum infiltration of the leaves with X-Gluc (Craig, 1992).

The results (Table 15) showed that in transient expression in soybean leaves, SCSV
20 segment 4 promoter was more active (25-35 spots/leaf) than the 35S promoter (10-15 spots/leaf) when the respective plasmids were shot into soybean leaves.

EXAMPLE 18**Testing of SCSV promoters for callus-specific expression**

25

All seven SCSV non-coding sequences were cloned into the promoterless *GUS* vector pHW9. Binary vectors each containing one of the seven SCSV promoter:*GUS* fusion constructs were transformed into tobacco tissues by *Agrobacterium*-mediated gene transfer. At 2-3 weeks after transformation, calli containing primordia of transformed
30 shoots were subjected to histochemical *GUS* staining. Best expression was observed in calli transformed with segment 1 followed by the S4nc:*GUS*:OCS constructs. This result suggests that the segment 1 promoter is best suitable for selectable marker gene

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expression and that the segment 4 promoter is best for gene expression.

EXAMPLE 19

Characterisation of regulatory sequences of the *Flaveria bidentis* MeA gene

5 In *Flaveria bidentis* (Chitty *et al.*, 1994) the MeA gene is the gene that codes for the NADP-malic enzyme adapted for C4 photosynthesis. The structure and putative promoter and transcription termination/polyadenylation signal sequences of this gene has been isolated and the terminator sequence determined (Fig. 15). The potential
10 activities of the putative promoter element (MeA 5' sequences [MeA 5']) and the terminator MeA 3' sequences [MeA 3']) of the *F. bidentis* MeA gene were studied in transgenic *F. bidentis* plants using GUS expression vectors (Fig. 16). A long version of the MeA 3' terminator sequence (MeA 3'L = 5.5kb from the stop codon) was used in these experiments. In Fig. 16, the GUS expression cassette ME20 is ligated to the
15 binary vector pGA470 (An *et al.*, 1985) while ME29 is cloned into pGA482 (An, 1986). Plants were transformed with these vectors as described by Chitty *et al.* (1994)

Study of GUS activity of the transformed plants by histochemical staining and fluorometric assays showed that the MeA 3' sequence of the gene is required for high
20 level expression of GUS in leaves of transgenic *F. bidentis* plants (Table 16). The 5' sequences of the gene do not appear to contribute to gene expression in leaves but appear to direct expression in meristems and stems in the presence of a suitable transcription termination/polyadenylation signal sequence such as the OCS 3' (Table 16).

25

EXAMPLE 20

Use of the MeA 3' termination/polyadenylation signal sequences in SCSV promoter constructs to enhance gene expression in monocotyledenous plants

30 Because most gene control elements are located at the 5' end, the activity of the MeA 3' sequence is tested in conjunction with the S4nc SCSV promoter with the view to enhance gene expression directed by the SCSV promoters. For these experiments, a

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short version of the MeA 3' terminator sequence was used (MeA 3'S; 900 bases from the stop codon) to prepare GUS expression vectors containing the S4nc promoter with either the OCS 3', SCSV segment 5 3' (SC5Tr) or the MeA 3' transcription termination/polyadenylation signal sequence. These constructs were derived from the promoterless GUS plasmid pKGO described previously and the recombinant plasmid pBS237 containing the S4nc:*GUS*:MeA3' construct is presented in Fig. 17. GUS activity conferred by these constructs were assayed in Japonica rice callus cv. Taipei 309. The constructs were introduced into rice calli by particle bombardment using the Bio-Rad Biolistic PDS-1000/He Particle Delivery System (Bio-Rad Laboratories) and compared with results obtained in dicotyledonous tissues such as soybean leaves and tobacco protoplasts (Table 17). For rice particle bombardment experiments, 4 mg of a 1:1 ratio of 1 and 5 micron gold particles plus 5 ug of DNA in a total of 50ul volume was shot onto six plates of calli. The DNA was made up with a 4:1 molar ratio of each of the vectors containing GUS gene to the vector containing the selectable marker gene. The vector containing the selectable marker was pTRA151 (Zheng *et al.*, 1991). Each plate contained 50-100 fresh secondary calli derived from mature embryos. Forty hours after DNA bombardment, GUS activity was detected by placing the calli in 0.3% w/v X-Gluc solution in 100 mM phosphate buffer. Blue spots were counted after overnight incubation.

For transient GUS expression in tobacco and soybean, only the GUS constructs were introduced into protoplasts and leaf tissues, respectively. After electroporation, tobacco protoplasts were assayed for GUS activity as previously described. The constructs were introduced into soybean tissues by particle bombardment as described above.

The results showed that in the monocotyledonous rice tissues, a 16-fold higher activity was obtained with the MeA 3' construct compared to the SCSV terminator (Table 17). In similar experiments, a highly expressed GUS construct containing the ubiquitin promoter:*GUS*:NOS cassette (Christensen *et al.*, 1992) has about 4-fold higher activity than the SC4:*GUS*:MeA3' construct.

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In the dicotyledonous tissues, similar activities were obtained with both of these constructs in tobacco protoplasts and soybean leaves. However, both were 2-fold higher in activity than that obtained with the OCS terminator in tobacco protoplasts (Table 17).

5

These results suggest that the MeA3' sequence can be used to enable gene expression directed by SCSV promoters in monocots.

EXAMPLE 21

10 Use of new vectors containing SCSV promoters and terminators to drive a selectable marker gene in transgenic plants

The suitability of using SCSV promoters to drive a selectable marker gene as a basis for selecting transgenic plants after transformation and regeneration was tested in tobacco plants. The selectable marker used is the kanamycin resistance gene, *nptII*. Binary vectors containing either a SCSV segment 1 (pBS246) (Fig. 18) or a SCSV seg 7 promoter (pKHAN4) (Fig. 19) fused to the *nptII* gene were constructed from the pART27 (Gleave, 1992) and pKSB.bar1 (Figure 19), respectively. These were transformed separately into tobacco plants (Ellis *et al.*, 1987) and putative transgenic plants were selected under kanamycin selection using 100 µg/ml kanamycin (Fig. 20). Kanamycin resistance was confirmed in the transgenic plants by dot blot assay for the *nptII* gene activity (McDonnell *et al.*, 1987) and survival of the transgenic plants under 100µg/ml kanamycin in a rooting medium. The results showed that the SCSV segment promoter construct produced at least as many kanamycin resistant plants as the 35S promoter construct use in the same experiment and is, therefore, as effective as the 35S promoter for selecting transgenic tobacco plants based on kanamycin resistance (Table 18). Tobacco transformed with pKHAN4 is resistant to 100 µg/ml kanamycin in regeneration medium and 50 µg/ml kanamycin in rooting medium. Restriction maps of pKSB.bar1 and pKHAN2 used to produce pKHAN4 are shown in Figure 19.

EXAMPLE 22**Development of a new plant gene expression vector system**

- 5 A new expression vector comprising a SCSV segment 4 promoter and a SCSV segment 5 terminator driving any useful gene of interest (pICAN 1) (Fig. 21) has been constructed from a pGEM derivative and the resultant expression cassette can be inserted into the binary vectors pBS246 and pKHAN4. The resultant binary vectors can then be used to transform plants of economic importance especially cotton,
- 10 subclover, potato and white clover under kanamycin selection. Other binary vectors can be constructed from different combinations of SCSV promoters and terminators to produce a full range of binary vector system for plant gene expression.

TABLE 8

Sequences and positions of PCR primers for cloning non-coding regions and corresponding PCR fragment sizes.

Primer name	Position of 5' end	Primer 1 sequence (5'-3')	Primer 2 name	Position of 5' end	Primer 2 sequence (5'-3')	Fragment size (bp)*
S1nc3	241	GGCGTGCCTCGGCCATGG	S1nc5	577	GGCGTGCCTCGGGGATCCTA	665
		CGCTATGAAATCTGAAC			TGTTGTAATTTTATATGG	
S2nc3	79	GGCGTGCCTCGGCCATGG	S2nc5	924	GGCGTGCCTCGGGGATCCA	177
		AAGCTTAGAGAGAGAAAG			ATAAAGAATATATATTATG	
S3nc3	374	CTCACTATAGAACCATGGA	S3nc5	863	CTCACTAAAGGGGATCCTG	502
		CACAAGATTCTAAG			AGATGTAATTGTG	
S4nc3	347	CTCACTATAGAACCATGGA	S4nc5	803	CTCACTAAAGGGGATCCTA	546
		AACGCAGAACAAAG			ATTGTTATTATCA	
S5nc3	372	CTCACTATAGAACCATGGT	S5nc5	874	CTCACTAAAGGGGATCCTA	523
		CGTTGTAATGAC			ATTGTGATGATT	
S6nc3	50	CTCACTATAGAACCATGGT	S6nc5	903	CTCACTAAAGGGGATCCTG	164
		GGGCCAGGGAAGCGA			AAACTCTGCGAA	
S7nc3	383	CTCACTATAGAACCATGGC	S7nc5	817	CTCACTAAAGGGGATCCTA	554
		TAAAACCCAGAAACA			ATTAATAGTAATTATG	

* not including the spacer nucleotides at the 5' ends of the primers

TABLE 9

GUS activity of SCSV segment 7 promoter:GUS construct in primary transgenic subterranean clover plants (To)

5	Plant #	Basta Resistance	GUS Activity
	1	R	+++
	2	R	++
	3	R	-
10	4	R	++
	5	S	++
	6	R	-
	7	R	++++
	8	R	++++
15	9	MR	+++
	10	R	+++
	11	R	+++
	12	MR	-
	13	MR	++
20	14	S	++
	15	R	+
	16	N.d.	++++
	17	N.d.	+++
	18	N.d.	-
25	19	N.d.	+++
	20	N.d.	++
30	Plants were analysed two months after transfer of plants to glasshouse from tissue culture. Basta (phosphinothricin - [PPT] resistance was assayed by painting basta at 1 gm PPT/litre onto fully unfolded young leaves and reaction was assayed after one week.		
	R	No damage;	
	MR	Moderate damage to leaflet;	
35	S	Leaflet dead	
	N.d.	Not determined	

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TABLE 10

GUS activity in tobacco protoplasts directed by SCSV segment 2 promoter
to tobacco protoplasts relative to the 35S promoter

5	Construct	GUS Activity	
		Experiment	
		1	2
10	S2nc: <i>GUS</i> :OCS3'	0.46	0.45
	35S: <i>GUS</i> :OCS3'	1	1

TABLE 11

5

Putative Polyadenylation and Termination signals in SCSV DNA Components

	DNA Component	Putative Polyadenylation/Termination Signals
10	Seg. 1	AATTAT <u>19</u> TGTGTTTT
	Seg. 2	AATAAA <u>10</u> TTGTTTT
	Seg. 3	AATAAA <u>3</u> TTGTT
	Seg. 4	AATAAA <u>8</u> TTATTGTT
	Seg. 5	AATAAA <u>3</u> TTGTTTT
15	Seg. 6	AATAAA <u>9</u> TTGTT
	Seg. 7	AATAAA <u>11</u> TTGTTT

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TABLE 12

GUS Activity Directed by SCSV Promoter in the presence of different terminators
in tobacco protoplasts

GUS ACTIVITY				
	Expt 1	Expt 2	Expt 3	Av
S4nc:GUS:OCS3'	551	166.3	-	358
S4nc:GUS:SC5Tr	1258	311.8	-	785
No DNA	0	0	0	0
S1nc:GUS:OCS3'	-	-	26	26
S1nc [Δ HindIII] ^a :GUS:OCS3'	-	-	29	29
S1nc [Δ HindIII]:GUS:SC3Tr	-	-	84	84
35S:GUS:OCS3'	-	-	35	35

In each experiment, duplicate electroporations of each construct was performed.
Results are the average of the duplicates.
^a Contains a deletion of a HindIII fragment.

TABLE 13

Fluorometric GUS Assay of Independent T1 generation of transgenic subterranean clover plants expressing either the S7nc:GUS or the 35S:GUS Construct

5	Construct/Plant #	Leaf (Young)	Petiole (Young)
		[unfolded]	[unfolded]
	S7nc:GUS Plant # 1	56.6	120
	S7nc:GUS Plant # 2	35	48
	S7nc:GUS Plant # 3	116	140
	35S:GUS Plant # 1	120	238
10	35S:GUS Plant # 2	280	238

Plants were 2 - 3 months old when assayed.

Results show differential expression in different tissues.

15

TABLE 14

Distribution of GUS activity in a T1 generation transgenic subterranean clover plant expressing the S7nc:GUS construct

20	Source of Tissue	Leaf	Petiole	Stem
	Top - [folded leaf; #1 leaf position]	1	1.9	2.0
25	Middle [#8 leaf position]	1.6	5.8	22.0
	Bottom [#17 leaf position]	4.0	4.8	12.6

Plants were 2 - 3 months old when assayed.

30 Results show differential expression in different tissues.

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TABLE 15

Transient expression of GUS in soybean leaves directed by a SCSV promoter

Constructs	GUS Expression in soybean leaves * (# spots/leaf)
S4nc: <i>GUS</i> :SC5Tr	25 - 35
5 35S: <i>GUS</i> :35STr	10 - 15

* Results from one experiment in which spots from 3 leaves were counted in each treatment

TABLE 16

Characterisation of GUS activity directed by MeA 3'L sequence (5.5kb version) in
Transgenic *Flaveria bidentis* Plants

5	Constructs	GUS Expression
	MeA:GUS:MeA 3'L (ME24)	High GUS in leaves
		High GUS in meristem
		Moderate GUS in stems
	MeA:GUS:OCS 3'(ME20)	No GUS in leaves
		High GUS in meristem
10		Moderate GUS in stems

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TABLE 17

Transient expression of GUS in rice callus, soybean leaves and tobacco protoplasts showing enhancement of SCSV promoter activity by MeA 3's sequences in rice callus

5	Constructs	GUS Expression		
		Rice callus (Rel # spots)	Soybean leaves (Rel # spots)*	Tobacco protoplasts (Fluorescence)
	S4nc:GUS:OCS 3'	ND ^a	ND	0.49
	S4nc:GUS:SC5Tr	0.06	1	1.0
	S4nc:GUS:MeA 3'S	1	1	1.1

10

ND Not done

* Average number of spots from 3 leaves in one experiment

TABLE 18

Selection of putative transgenic tobacco plants transformed with Kanamycin resistance gene driven by 35S or S4nc promoter.

Selection Criteria	Constructs	% Kanamycin resistant
npt II dot Blot	35S:npt II:35STr	(1/3)* 33%
	S4nc:npt II:SC3Tr	(7/16) 43%
Kanamycin selection in rooting medium	35S:npt II:35STr S4nc:npt II:SC3Tr	(10/21) 48% (11/21) 52%

* Number of resistant plants in total number of plants tested.

TABLE 19
Summary of the activities of SCSV transcription regulatory elements in plant tissues

A.	SCSV promoter	Gene Expressed	Protoplasts	Activity Detected	
				Transgenic Plants	Transgenic Plants
	Seg 1	GUS, nptII	Tobacco		Tobacco
	Seg 2	GUS	Tobacco		Tobacco
	Seg 3	GUS	Not done		Tobacco
	Seg 4	GUS	Tobacco		Tobacco, potato
	Seg 5	GUS	Tobacco, subclover		Tobacco
	Seg 6	None	Not done		Not done*
	Seg 7	GUS, nptII	Tobacco, subclover		Tobacco, subclover, cotton
B.	SCSV Terminator	Gene Expressed	Protoplasts	Activity Detected	
				Transgenic Plants	Transgenic Plants
	SC3Tr	GUS, nptII	Tobacco		Tobacco
	SC5Tr	GUS	Tobacco		Not done

* Sequence used probably insufficient to be active. Additional DNA sequence may be required as shown in segment 2.

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SEQUENCE LISTING

(I) GENERAL INFORMATION:

(i) APPLICANT: COMMONWEALTH SCIENTIFIC AND INDUSTRIAL
RESEARCH ORGANISATION

(ii) TITLE OF INVENTION: NOVEL PLANT PROMOTERS AND USES
THEREFOR

(iii) NUMBER OF SEQUENCES: 7

(iv) CORRESPONDENCE ADDRESS:

(A) ADDRESSEE: DAVIES COLLISON CAVE
(B) STREET: 1 LITTLE COLLINS STREET
(C) CITY: MELBOURNE
(D) STATE: VICTORIA
(E) COUNTRY: AUSTRALIA
(F) ZIP: 3000

(v) COMPUTER READABLE FORM:

(A) MEDIUM TYPE: Floppy disk
(B) COMPUTER: IBM PC compatible
(C) OPERATING SYSTEM: PC-DOS/MS-DOS
(D) SOFTWARE: PatentIn Release #1.0, Version #1.25

(vi) CURRENT APPLICATION DATA:

(A) APPLICATION NUMBER: AU PROVISIONAL
(B) FILING DATE: 07-NOV-1994

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(A) APPLICATION NUMBER: PM7770/94
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- 57 -

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1001 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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TAGTATTACC CCCGTGCCGG GATCAGAGAC ATTTGACCAA TAGTTGACTA GTATAATAGC   60
CCTTGGATTA AATGACACGT GGACGCTCAG GATCTGTGAT GCTAGTGAAG CGCTTAAGCT   120
GAACGAATCT GACGGAAGAG CGTTCACACT TAGATCTAGT TAGCGTACTT AGTACGCGTT   180
GTCTTGGGTC TATAAATAGA GTGCTTCTGA ACAGATTGTT CAGAATTTCA TAGCGAGATG   240
GATTCTGGTG ATGGTTACAA TACATACTCA TATGAAGAAG GTGCTGGAGA TGCGAAGAAG   300
GAAGTTTTAT ATAAATAGG TATTATTATG TTATGTATTG TAGGGATTGT AGTTTTATGG   360
GTTTTAATTA TATTATGTTG TGCTGTTCTT CGCTATGCTA AATCAACGAT GGACGCTTGG   420
TTATCTTCGT CTTCTATTAT GAAGAGGAAG ATGGCTTCAA GGATTACTGG TACTCCGTTT   480
GAAGAACTG  GTCCTCATCG TGAAAGAAGA TGGGCTGAAA GAAGAACTGA AGCGACGAAC   540
CAGAATAATA ATGATAATGT AATAGATTT AGTTGATATG TTGTAATTTT ATATGGATTA   600
ATGAGAATTA TTATTATTCT GTTCTTCGTC TGTGTTTTTT AAGCTTTTTT TGTGTTTTAA   660
TGGCGTCTGG AGAGAGAAAG GAATAATTGT AAGGTAGACG ACGATGTAGT GGATTACAGT   720
TGTCTTTACT TCGCCTCGAA GAAAGACACA TTTCAAGTTG TGAGTGTAT TGTCTTTGAG   780
GAAGCTTCCT CGAAGCAGCG TATAACTTTA ATTTGAATTT GGTTTTGGCG CGTTAGTGAA   840
ATTGCGGCTG TAAACGTGTC AAGTTGTGAG TGGCTGAAAT AAGATAATAG ATATATTATT   900
ATTGTTTTAA TTTAATTCCG CGAAGCGATA TGTTAAGTGA TAAATGAAAC GAAGCGTTTT   960
GATGACGTCA TATGTCTCCG TGCCTACGTC AGCACGGGGC T                               1001
```

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(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1022 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

```
TAGTATTACC CGACCTTGCC ACACCTCCTT GGAACACTTT CTCTCTCTAG AAAGTGTGAG      60
ACTTTCTCTC TCTAAGCTTA TATGGCTAGA AGGTACTGTT TTACATTAAA TTACGCTACT      120
GAGATAGAGA GAGAAACATT CCTCTCCCTC TTCTCTCAAG ACGAATTAAA CTATTTTCGT      180
GTCGGCGACG AAACCTGCAAC TACTGGACAG AAACACCTCC AGGGATTTGT ATCGTTCAAG      240
AACAAAATTC GTCTTGGTGG ATTGAAGAAG AAATTTGGTA ATCGAGCTCA CTGGGAAATT      300
GCGAGAGGCA GCGATTCTCA GAATCGCGAT TATTGCTGTA AAGAAACCCT AATTTCTGAA      360
ATTGGGATTC CGGTCATGAA GGGTTCGAAC AAGCGGAAGA CGATGGAGAT TTATGAAGAG      420
GATCCCGAAG AAATGCAATT GAAGGATCCA GATACTGCTC TTCGATGTAA GGCGAAGAAA      480
TTGAAAGAGG AATATTGTTT CTGTTATGAT TTTCAGAAAC TCCGTCCATG GCAAATTGAG      540
CTTCACGAGG ATTTAATGGC GGAACCAGAT GATCGGAGTA TCATCTGGGT CTATGGTTCA      600
GACGGAGGAG AAGGAAAGAC GAGCTTCGCG AAGGAATTAA TCAGGTATGG ATGGTTTTAT      660
ACAGCCCGAG GGAAGACCCA GGACGTATTA TATATGTATG CTCAAGACCC AGAGAGGAAT      720
ATTGCGTTTG ATGTTCCAG GTGTTCTTCG GAGATGATGA ACTATCAGGC GATGGAGATG      780
TTGAAGAACA GAGTTTTTGC AAGTACAAAA TATAGGCCTG TAGATCTTTG TATTAGGAAG      840
TTAGTTCATT TAATTGTGTT TGCCAACGTG GCACCTGACC CCACGCGCAT AAGTGAGGAC      900
AGACTTGTA TATCAATTG TTGAATAAAA GAATATATAT TATTGTTTTA ATTTAATTCC      960
GCGAAGCGGT AGCCGGTCAT AACACTGTTG CCCTTGGAAC ACTATATATA GCAAGGTCGG     1020
CT                                                                           1022
```

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(2) INFORMATION FOR SEQ ID NO:3:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 991 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(11) MOLECULE TYPE: DNA

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:3:

TAGTATTACC CCCGTGCCGG GATCAGAGAC ATTTGACCAA TAGTTGACTA TGAATAATAG	60
CCCTTGGATT AGATGACACG TGGACGCTCA GGATCTGTGA TGCTAGTGAA GCGCTTAAGC	120
TGAACGAATC TGACGGAAGA GCGGACATAC GCACATGGAT TATGGCCAC ATGTCTAAAG	180
TGTATCTCTT TACAGCTATA TTGATGTGAC GTAAGATGCT TTACTTCGCC TCGAAGTAAA	240
GTAGGAAATT GCTCGCTAAG TTATTCTTTT CTGAAAGAAA TTAATTAAAT TCTAAATTAA	300
ATTAAATGAG TGGCTATAAA TAGATGTTTC GTCTTCGTTG TTTTACAACG AAGCTTAGAA	360
TCTTGTTTA ATGGCGTTAA GGTATTTCTC TCATCTTCCT GAAGAACTGA AGGAGAAGAT	420
TATGAACGAG CACTTGAAGG AAATTAAGAA GAAGGAATTT CTAGAGAATG TAATTAAAGC	480
TGCGTGTGCT GTGTTTGAAG GTTTAACAAA GAAGGAGTCT GTTGAAGAAG ACGACATACT	540
ACGCTTCTCT GGGTTTCTGG AAGGTCTGTC TGCATATTAT GCAGAGGCCA CGAAGAAGAA	600
GTGTTTAGTT AGATGGAAGA AGAGCGTTGC AATAAATCTG AAATGGAGAG TTATGGAGGA	660
GATGCATTAC AAGCTTTATG GATTTGCAGA CATGGAAGAT TTATATTATT CAGAGTTAGG	720
GTTTCCTAAT TACGGTGAAG ACGATGTAGC TTATCACGAT GGTGCAATTG TAAATTGTAA	780
GCAATTAGAA GTTGTATTTG ATGATTTAGG TATTGAGTTT ATGTCTATTG TAATTGATAG	840
AGGTTCTATT AAGATAGAAT TATGAGATGT AATTGTGATT AATGAATAAA GAGTTGTTAT	900
TATTCTTTGA ATTACTCCGC GAAGCGGTGT GTTATGTTTT TGTGGAGAC ATATGACGTC	960
ATATGTCTCG CCGACAGGCT GGCACGGGGC T	991

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(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1002 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

```
TAGTATTACC CCGTGCCGGG ATCAGAGACA TTTGACTAAA TGTTGACTTG GAATAATAGC      60
CCTTGGAATTA GATGACACGT GGACGCTCAG GATCTGTGAT GCTAGTGAAG CGCTTAAGCT      120
GAACGAATCT GACGGAAGAG CGGACAAACG CACATGGACT ATGGCCCACT GCTTTATTAA      180
AGAAGTGAAT GACAGCTGTC TTTGCTTCAA GACGAAGTAA AGAATAGTGG AAAACGCGTA      240
AAGAATAAGC GTACTCAGTA CGCTTCGTGG CTTTATAAAT AGTGCTTCGT CTTATTCCTC      300
GTTGTATCAT CAACGAAGAA GTTAAGCTTT GTTCTGCGTT TTAATGGCGG ACTGTTTCA      360
CAGTGCCTT AAGACATGTA CTCATGCTG TGATTTTTCA GATATTAAGG CGTCTTCACA      420
ACAGGATTTT TCTGTTGTG ATAGTATGCG AGGTAAATTA TCTGAACCTA GGAAGGTGTT      480
GTTAGTTAGT TGTTTTGTAA GTTTTACTGG TAGTTTTTAT GGAAGTAATA GGAATGTTAG      540
AGGTCAAGTT CAGTTGGGTA TGCAGCAAGA TGATGGCGTT GTTCGTCCAA TAGGATATAT      600
TCCTATTGGG GGTATTGTT ATCATGATGA TTATGGATAT TATCAAGGAG AGAAGACGTT      660
CAATCTGGAC ATCGAGTCAG ATTATCTGAA GCCTGATGAA GATTTTTGGA AGAGATTTAC      720
AATTAATATT GTAAATGATA AAGGATTAGA TGATAGGTGT GATGTAAAAT GTTATGTAGT      780
TCATACGATG CGTATTAAAG TGTAATTGTT ATTATCAATA AAAGAATTTT TATTGTTATT      840
GTGTTATTTG GTAATTTATG CTTATAAGTA ATTCTATGAT TAATTGTGAA TTAATAAGAC      900
TAATGAGGAT AATAATTGAA TTTGATTAAA TTAAGTCTGC GAAGCTATAT GTCTTTCACG      960
TGAGAGTCAC GTGATGTCTC CGCGACAGGC TGGCACGGGG CT                          1002
```

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(2) INFORMATION FOR SEQ ID NO:5:

- (i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 998 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

TAGTATTACC CCGTGCCGGG GTCAGAGACA TTGACTAAA TATTGACTTG GAATAATAGC	60
CCTTGGATTA GATGACACGT GGACGCTCAG GATCTGTGAT GCTAGTGAAG CGCTTAAGCT	120
GAACGAATCT GACGGAAGAG CGTCATGGTC CACATGTCTA AAGAATAATG CTTTACAGCT	180
GTATTGATTT GACTTTACGC GCTTTACTTT AATTGCTTTA AGTAAAGTAA GATGCTTTAC	240
TTTGCTCGCG ACGAAGCAAA GTGATTGTAG CTGCAGAAAT TGATGCTTTA ATTACCGGGT	300
AACACGGTTT GATTGTGGGT ATAAATATGT TCTGTCGTT TTCTTCGTTG TCATTTTACA	360
ACGAAGATGG TTGCTGTTCC ATGGGGAAGA AAGGGTCTGA GGTCTCAAAG GAGAAAATAT	420
TCGCGAATTG CTTACAAACC TCCTTCGTCT AAGGTTGTAA GTCATGTGGA GTCTGTTCTG	480
AATAAGAGAG ATGTTACTGG AGCGGAGGTT AAGCCATTCC CTGATGGTTC AAGGTATAGT	540
ATGAAGAAGG TAATGTTGAT TGCAACATTA ACTATGGCTC CTGGAGAATT AGTTAATTAT	600
CTTATTGTGA AGAGTAATTC GCCTATTGCG AATTGGAGTT CGTCTTTCAG TAATCCTTCG	660
TTGATGGTGA AAGAGTCTGT TCAAGATACA GTTACGATTG TTGGAGGAGG AAAGCTTGAG	720
TCTTCTGGTA CTGCTGGTAA AGATGTAAC TAACTCTTTA GGAAGTTTGT TAAGCTGGGT	780
TCAGGTATTA GTCAGACCCA GCATTTGTAT TTAATTATTT ATTCCAGTGA TGCGATGAAG	840
ATCACACTGG AGACGAGAAT GTATATTGAT GTATAATTGT GATGATTAAT GAATAAGAG	900
TTGTTTTTAT TCTTTGAATT ACTCCGCGAA GCGGTGTGTT ATGTTTTTGT TGGAGACATA	960
TGACGTCATA TGTCTCCGCG ACAGGCTGGC ACGGGGCT	998

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(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1017 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

CAGTATTACC GCACCTCGCT TACCCTCCTC GCTTCCCTGG GCCCACTATG CCTACTAGAC	60
AAAGCACTAG TTGGGTGTTT ACACTTAACT TTGAGGGCGA AATTCCTATT TGCCCTTTA	120
ATGAAAGCGT TCAGTACGCT TGTGGCAGC ATGAGAGAGT GGGACACGAT CATTACAGG	180
GATTTATACA ATTTAAATCC CGCAACACTA CATTGCGTCA GGCTAAGTAT ATTTTAAATG	240
GACTGAATCC TCATCTGGAA ATGCTAGGG ATGTAGAGAA GGCAGCAATTG TACGCGATGA	300
AGGAAGATAG TAGAGTAGCT GGTCCCTGGG AGTATGGGTT GTTTATTAAG AGAGGATCGC	360
ATAAGCGTAA GCTGATGGAG AGATTTGAAG AAGATGGAGA AGAGATGAAA ATTGCTGATC	420
CCTCTCTCTA TAGGCGTTGT CTATCAAGGA AGATGGCTGA AGAACAACGT TGTTCTTCTG	480
AGTGAATTA TGACTTACGC CCTTGGCAAG AAGAAGTGAT GCATTTGTTA GAGGAAGAAC	540
CAGATTATAG AACGATAATC TGGGTGTATG GACCTGCTGG TAATGAAGGC AAATCTACAT	600
TTGCAAGACA TCTGTCATTG AAAGATGGTT GGGGTTATCT GCCTGGAGGA AAGACACAAG	660
ATATGATGCA TCTGTGACT GCTGAGCCTA AGAATAATTG GGTATTTGAC ATACCCAGAG	720
TTAGTTCAGA GTATGTGAAT TATGGTGTAA TAGAACAGGT TAAGAATAGG GTAATGGTGA	780
ATACTAAGTA TGAGCCATGT GTAATGCGGG ATGATAATCA TCCTGTTTAT GTAATTGTGT	840
TTGCAAATGT ACTCCAGAT TTGGGAAAAT TAAGTGAAGA TAGAATAAAA TTAATTCGTT	900
GTTGAAAACCT CTGCGAAGGC AGAAGTTATA AAAAAAATGT GTTTTGAGAG AAGTCCCACA	960
TCGGGTAGTT CGCGAAACAG GGTGAGGGAA GCGAGCAATA TAAGGCGAGG TGCATAT	1017

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(2) INFORMATION FOR SEQ ID NO:7:

- (i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 988 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

TAGTATTACC CCGTGCCGGG ATCAGAGACA TTTGACTAAA TATTGACTTG GAATAATAGC	60
CCTTGGATTA GATGACACGT GGACGCTCAG GATCTGTGAT GCTAGTGAAG CGCTTAAGCT	120
GAACGAATCT GACGGAAGAG CGGACATACG CACATGGATT ATGGCCCCACA TGTCTAAAGT	180
GTATCTCTTT ACAGCTATAT TGATGTGACG TAAGATGCTT TACTTCGCTT CGAAGTAAAG	240
TAGGAAATTG CTCGCTAAGT TATTCTTTTC TGAAAGAAAT TAATTTAATT CTAATTAAAT	300
TAAATGAGTG GCTATAAATA GTGTCGATGC TGCCTCACAT CGTATTCTTC TTCGCATCGT	360
CTGTTCTGGT TTTAAGCGAT GGTCACTTTT AGTTTTCCTG AGATATACGA TGTGAGCGAC	420
GATGTTCTTG TAAGCGATAG CAGAAGAAGT GTAGCTGTTG AGGTCGAAGA GAAGGTTCAA	480
GTGATTAACG TGAAGGTACT GAGGTTGATT GAAGCTGTTG ATGAAGATAG AGTTGGAGTG	540
AAGGTTATGT TTCGTCTGTG TTACAGATAC AGACGAGAAC TGAAGATTAC GTTGTGGGT	600
TGTAAGATGG AGCTATGGAC TTCGTTGAAG TCTTCAGGCA AGTATTCAGT TCAATCTTTG	660
TTGCAGAGGA AGCTTAATGG TATATGTGTT AGTAATTACT GTATAGGTAT TGATATGTTT	720
GTAAGTAATG TTAAGAGATT GATTAATAGA TGTAATGGA TTACATCTGT TCAAGGTGTT	780
AATCCTATAT GTTGTGTTGA TCATATGGAC GAAGAGTAAT TAATAGTAAT TATGATTAAT	840
TATGAGATAA GAGTTGTTAT TAATGCTTAT GAGGAATAAA GAATGATTAA TATTGTTTAA	900
TTTTATTTCG GAAGCGGTGT GTTATGTTTT TGTGGAGAC ATCACGTGAC TCTCACGTGA	960
TGTCTCCGCG ACAGGCTGGC ACGGGGCT	988

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CLAIMS:

1. A genetic construct comprising a circovirus promoter which is operable in a plant cell.
2. A genetic construct according to claim 1 wherein the circovirus genome comprises more than two DNA components or segments.
3. A genetic construct according to claim 2 wherein the circovirus is subterranean clover stunt virus (SCSV).
4. A genetic construct according to claim 3 wherein the promoter is selected from one of segments 1 to 7 of SCSV as defined by SEQ ID NOs: 1 to 7 or the promoter is capable of hybridizing thereto under low stringency conditions.
5. A genetic construct according to claim 1 or 2 or 3 or 4 further comprising a termination and/or polyadenylation sequence such that said sequence is operably linked to a gene when said gene is operably linked to said promoter.
6. A genetic construct according to claim 5 wherein the termination and/or polyadenylation sequence is of SCSV origin.
7. A genetic construct according to claim 5 wherein the termination and/or polyadenylation sequence is selected from one of segments 1 to 7 of SCSV as defined by SEQ ID NOs: 1 to 7 or the termination and/or polyadenylation sequence is capable of hybridizing thereto under low stringency conditions.
8. A genetic construct according to claim 5 wherein the termination and/or polyadenylation sequence is from the *Flaveria bidentis* MeA gene.
9. A genetic construct according to claim 1 or 2 or 3 or 4 further comprising a heterologous gene operably linked to said promoter.

10. A genetic construct according to claim 5 further comprising a heterologous gene operably linked to said promoter and to said termination and/or polyadenylation sequence.

11. A genetic construct according to claim 6 or 7 or 8 further comprising a heterologous gene operably linked to said promoter and to said termination and/or polyadenylation sequence.

12. A genetic construct according to claim 9 or 10 or 11 wherein the heterologous gene is selected from:

- a) a resistance gene against plant viruses, bacteria, fungi, nematode and other pathogens;
- b) a plant virus resistance gene including a synthetic gene from and against alfalfa mosaic virus, subterranean clover stunt virus, subterranean clover mottle virus, subterranean clover red leaf virus, potato leafroll virus, tomato spotted wilt virus, bean yellow mosaic virus, white clover mosaic virus, clover yellow vein virus, potato viruses x, y, s, m and a, cucumber mosaic virus, rice ragged stunt virus and barley yellow dwarf viruses;
- c) a gene to improve nutritional value of plants such as sunflower high sulphur gene SF8;
- d) a bloat resistance gene;
- e) an antibody gene;
- f) a cereal thionin and ribosome inactivating protein gene;
- g) an insect resistance gene including BT toxin gene and proteinase inhibitor gene from *Nicotiana glauca*;
- h) a selectable marker gene such as those conferring resistance to kanamycin, phosphinothricin, spectinomycin and hygromycin;
- i) a reporter gene such as GUS, CAT and pigment genes;
- j) a gene encoding a regulatory protein which modulates expression of a gene in plant cells.

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13. A genetic construct comprising an SCSV promoter operable in a plant cell, at least one restriction endonuclease site downstream of said promoter to facilitate insertion of a heterologous gene operably linked to said promoter and optionally a termination and/or polyadenylation sequences located at the 3' end of a heterologous gene when said gene is inserted into said restriction endonuclease site.
14. A genetic construct according to claim 13 wherein the promoter is selected from one of segments 1 to 7 of SCSV as defined by SEQ ID NOs. 1 to 7 or the promoter is capable of hybridizing thereto under low stringency conditions.
15. A genetic construct according to claim 13 or 14 wherein the termination and/or polyadenylation sequence is of SCSV origin.
16. A genetic construct according to claim 15 wherein the termination and/or polyadenylation sequence is selected from one of segments 1 to 7 of SCSV as defined by SEQ ID NOs: 1 to 7 or the termination and/or polyadenylation sequence is capable of hybridising thereto under low stringency conditions.
17. A genetic construct according to claim 13 wherein the termination and/or polyadenylation sequence is from the *Flaveria bidentis* MeA gene.
18. A genetic construct according to claim 13 further comprising a heterologous gene selected from:
- a) a resistance gene against plant viruses, bacteria, fungi, nematode and other pathogens;
 - b) a plant virus resistance gene including synthetic genes from and against alfalfa mosaic virus, subterranean clover stunt virus, subterranean clover mottle virus, subterranean clover red leaf virus, potato leafroll virus, tomato spotted wilt virus, bean yellow mosaic virus, white clover mosaic virus, clover yellow vein virus, potato viruses x, y, s, m and a, cucumber mosaic virus, rice ragged stunt virus and

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barley yellow dwarf viruses;

- c) a gene to improve nutritional value of plants such as sunflower high sulphur gene SF8;
- d) a bloat resistance gene;
- e) an antibody gene;
- f) a cereal thionin and ribosome inactivating protein gene;
- g) an insect resistance gene including BT toxin gene and proteinase inhibitor gene from *Nicotiana glauca*;
- h) a selectable marker gene such as those conferring resistance to kanamycin, phosphinothricin, spectinomycin and hygromycin;
- i) a reporter gene such as GUS, CAT and pigment genes;
- j) a gene encoding a regulatory protein which modulates expression of a gene in plant cells.

19. A genetic construct comprising two or more heterologous genes operably linked to the same or different circovirus promoters operable in a plant cell.

20. A genetic construct according to claim 19 wherein the promoter or different promoters are from a circovirus with a genome comprising more than two components or segments.

21. A genetic construct according to claim 20 wherein the promoter or different promoters are from subterranean clover stunt virus (SCSV).

22. A genetic construct according to claim 21 wherein the promoter or different promoters are selected from one of segments 1 to 7 of SCSV as defined by SEQ ID NOs. 1 to 7 or the promoters are capable of hybridizing to at least one of SEQ ID NOs. 1 to 7 under low stringency conditions.

23. A genetic construct according to claim 19 or 20 or 21 or 22 further comprising a termination and/or polyadenylation sequence operably linked to one or more of said heterologous genes.

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24. A genetic construct according to claim 23 wherein the termination and/or polyadenylation sequences are the same for each gene.
25. A genetic construct according to claim 23 wherein the termination and/or polyadenylation sequences are different for each gene.
26. A genetic construct according to claim 24 or 25 wherein at least one termination and/or polyadenylation sequence is selected from segments 1 to 7 of SCSV as defined by SEQ ID NOs: 1 to 7 and the termination and/or polyadenylation sequences are capable of hybridizing to at least one of SEQ ID NOs. 1 to 7 under low stringency conditions.
27. A genetic construct according to claim 24 or 25 wherein at least one termination and/or polyadenylation sequence is from the MeA gene of *Flaveria bidentis*.
28. A genetic construct according to claim 19 wherein the heterologous genes are selected from:
- a) a resistance gene against plant viruses, bacteria, fungi, nematode and other pathogens;
 - b) a plant virus resistance gene including a synthetic gene from and against alfalfa mosaic virus, subterranean clover stunt virus, subterranean clover mottle virus, subterranean clover red leaf virus, potato leafroll virus, tomato spotted wilt virus, bean yellow mosaic virus, white clover mosaic virus, clover yellow vein virus, potato viruses x, y, s, m and a, cucumber mosaic virus, rice ragged stunt virus and barley yellow dwarf viruses;
 - c) a gene to improve nutritional value of plants such as sunflower high sulphur gene SF8;
 - d) a bloat resistance gene;
 - e) an antibody gene;
 - f) a cereal thionin and ribosome inactivating protein gene;
 - g) an insect resistance gene including BT toxin gene and proteinase inhibitor gene from *Nicotiana glauca*;
 - h) a selectable marker gene such as those conferring resistance to

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kanamycin, phosphinothricin, spectinomycin and hygromycin;

- i) a reporter gene such as GUS, CAT and pigment genes;
- j) a gene encoding a regulatory protein which modulates expression of a gene in plant cells.

29. A method of expressing a foreign gene in a plant cell, said method comprising introducing into said plant cell a genetic construct according to any one of claims 13 to 17 and further comprising said foreign gene operably linked to the promoter on said genetic construct.

30. A method according to claim 29 wherein the foreign gene is selected from:

- a) a resistance gene against plant viruses, bacteria, fungi, nematode and other pathogens;
- b) a plant virus resistance gene including a synthetic gene from and against alfalfa mosaic virus, subterranean clover stunt virus, subterranean clover mottle virus, subterranean clover red leaf virus, potato leafroll virus, tomato spotted wilt virus, bean yellow mosaic virus, white clover mosaic virus, clover yellow vein virus, potato viruses x, y, s, m and a, cucumber mosaic virus, rice ragged stunt virus and barley yellow dwarf virus;
- c) a gene to improve nutritional value of plants such as sunflower high sulphur gene SF8;
- d) a bloat resistance gene;
- e) an antibody gene;
- f) a cereal thionin and ribosome inactivating protein gene;
- g) an insect resistance gene including BT toxin gene and proteinase inhibitor gene from *Nicotiana glauca*;
- h) a selectable marker gene such as those conferring resistance to kanamycin, phosphinothricin, spectinomycin and hygromycin;
- i) a reporter gene such as GUS, CAT and pigment genes;
- j) a gene encoding a regulatory protein which modulates expression of a gene in plant cells.

31. A method of expressing two or more foreign genes in a plant cell, said method comprising introducing into said plant cell a genetic construct according to any one of claims 19 to 28.
32. A transgenic plant comprising a SCSV promoter and a heterologous gene operably linked thereto and optionally a terminator and/or polyadenylation sequence.
33. A transgenic plant according to claim 32 wherein said heterologous gene is selected from:
- a) a resistance gene against plant viruses, bacteria, fungi, nematode and other pathogens;
 - b) a plant virus resistance gene including a synthetic gene from and against alfalfa mosaic virus, subterranean clover stunt virus, subterranean clover mottle virus, subterranean clover red leaf virus, potato leafroll virus, tomato spotted wilt virus, bean yellow mosaic virus, white clover mosaic virus, clover yellow vein virus, potato viruses x, y, s, m and a, cucumber mosaic virus, rice ragged stunt virus and barley yellow dwarf virus;
 - c) a gene to improve nutritional value of plants such as sunflower high sulphur gene SF8;
 - d) a bloat resistance gene;
 - e) an antibody gene;
 - f) a cereal thionin and ribosome inactivating protein gene;
 - g) an insect resistance gene including BT toxin gene and proteinase inhibitor gene from *Nicotiana glauca*;
 - h) a selectable marker gene such as those conferring resistance to kanamycin, phosphinothricin, spectinomycin and hygromycin;
 - i) a reporter gene such as GUS, CAT and pigment genes.
 - j) a gene encoding a regulatory protein which modulates expression of a gene in plant cells.
34. A transgenic plant according to claim 32 or 33 wherein the terminator and/or polyadenylation sequence is from SCSV.

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35. A transgenic plant according to claim 32 or 33 wherein the terminator and/or polyadenylation sequence is from the *Flaveria biontis* MeA gene.
36. A transgenic plant comprising a genetic construct according to any one of claims 19 to 28.
37. An isolated nucleic acid molecule selected from SEQ ID NO. 1 to SEQ ID NO. 7 or the nucleic acid molecule is capable of hybridizing to at least one of SEQ ID NOs. 1 to 7 under low stringency conditions.
38. A method for enhancing the level of expression of a foreign gene operably linked to an SCSV promoter in a plant cell, said method comprising introducing to said cell a single or two different genetic constructs, comprising a gene to be expressed and a gene whose product is capable of enhancing or transactivating the expression of that gene.
39. A method according to claim 38 wherein the transactivating gene is selected from SEQ ID NO. 1 to SEQ ID NO. 7 or a gene capable of hybridizing thereto under low stringency conditions.

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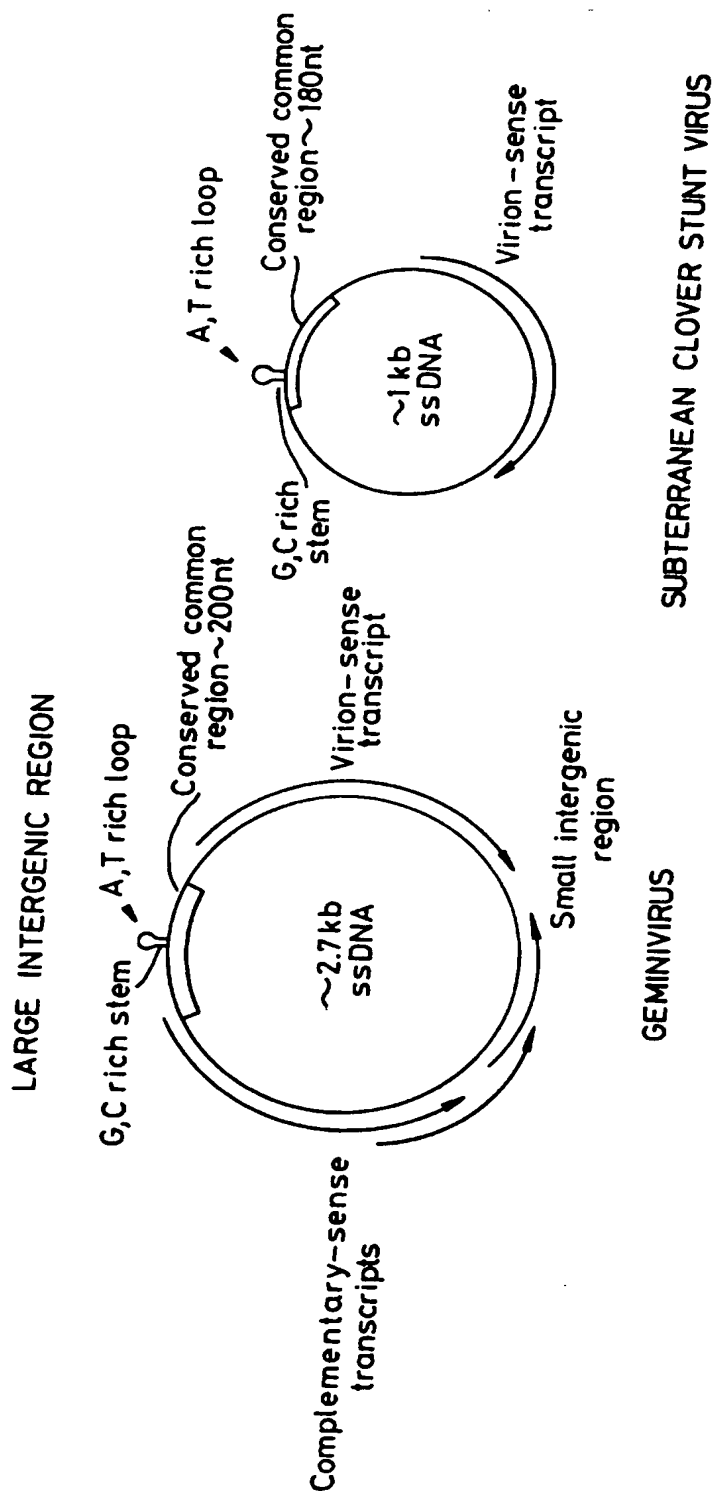


Fig.1

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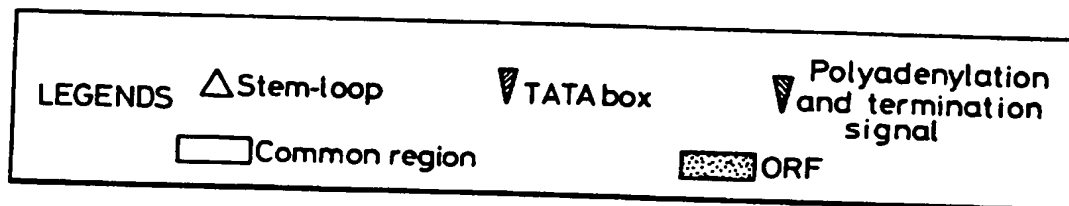
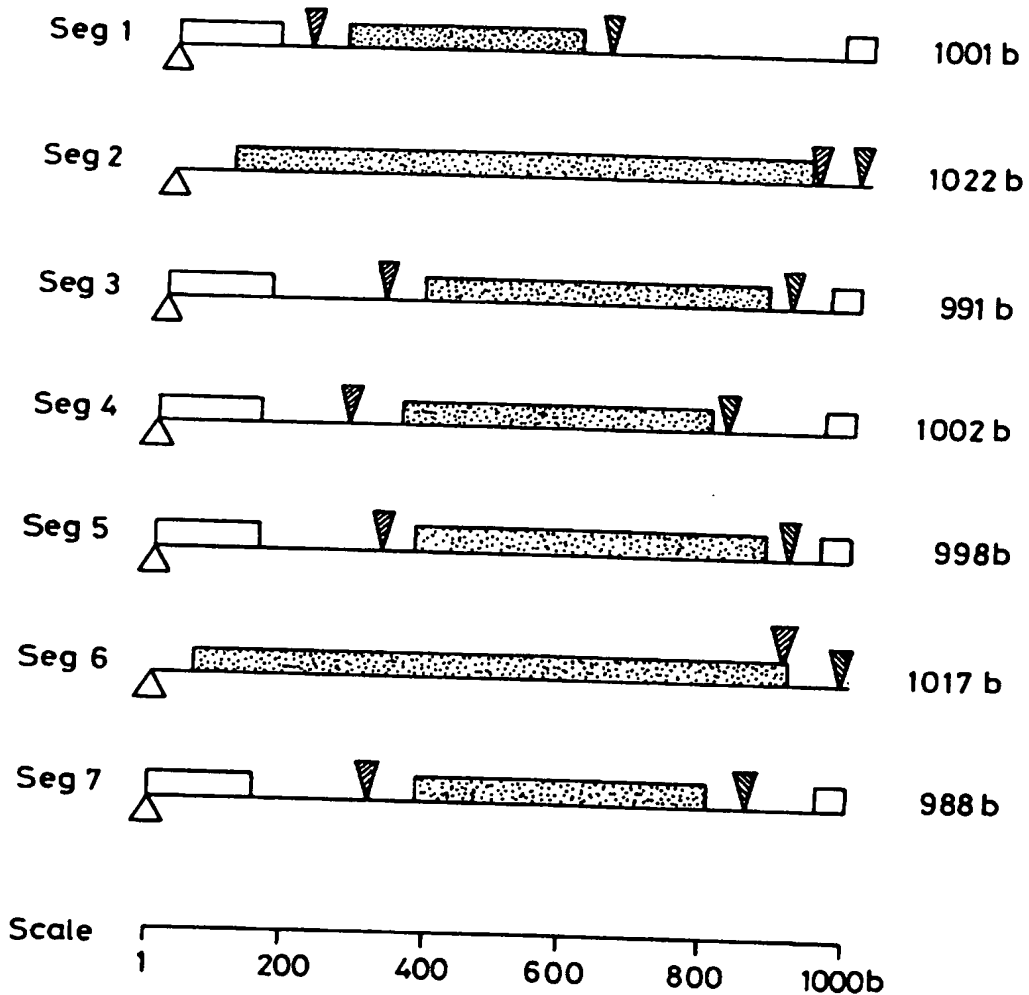


Fig. 2

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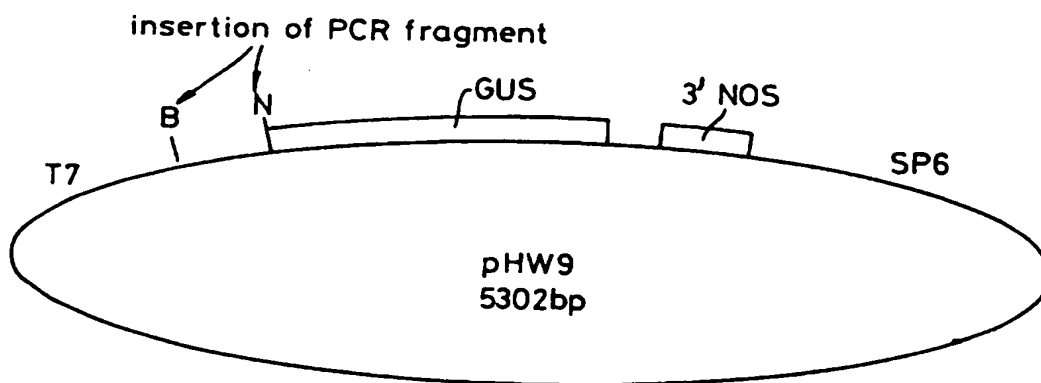
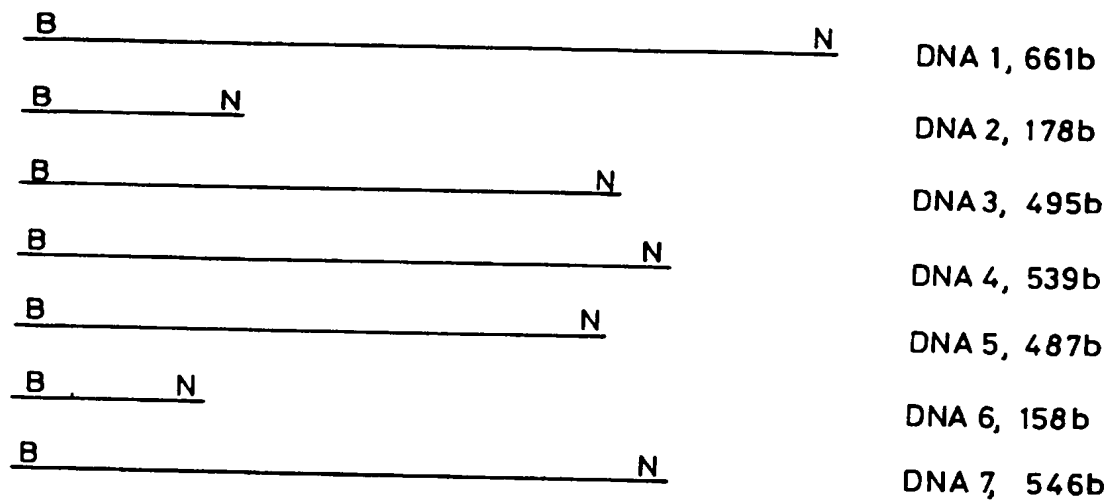
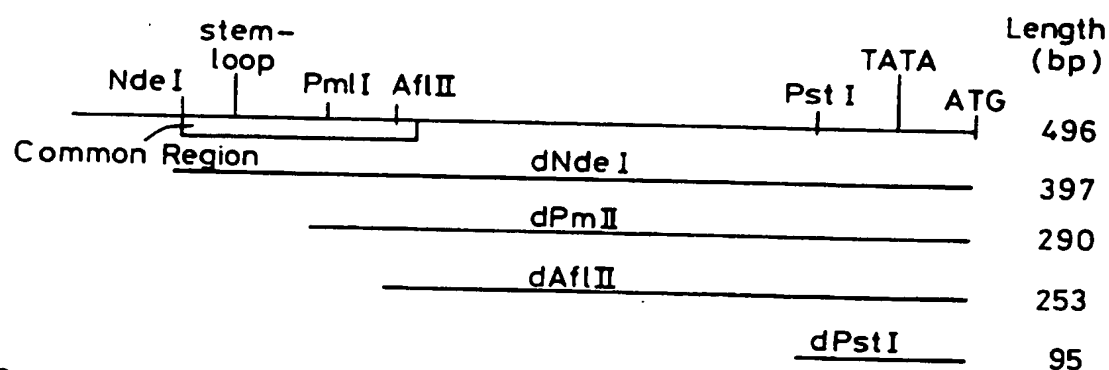


Fig. 3

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Component 5 non-coding region and deletions.



Component 7 non-coding region and deletion

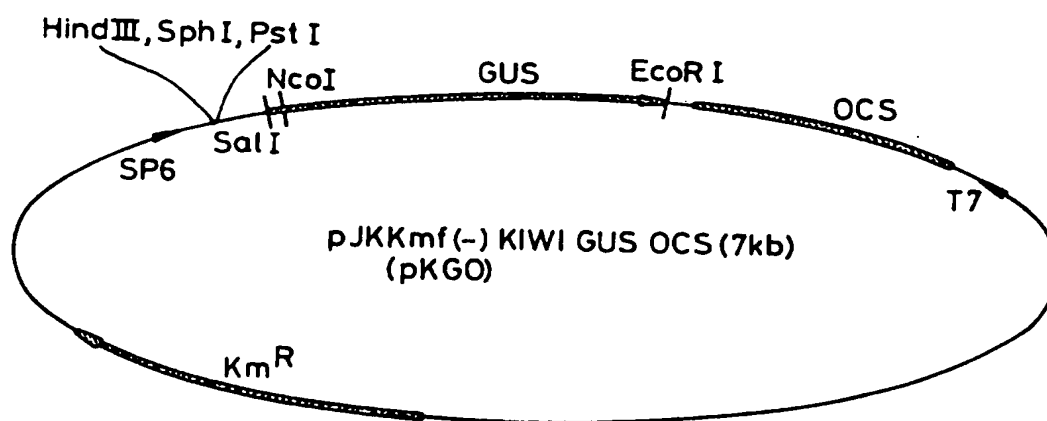
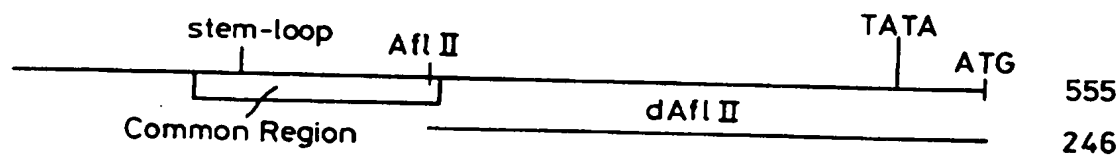


Fig.4

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Plasmid pBs 150

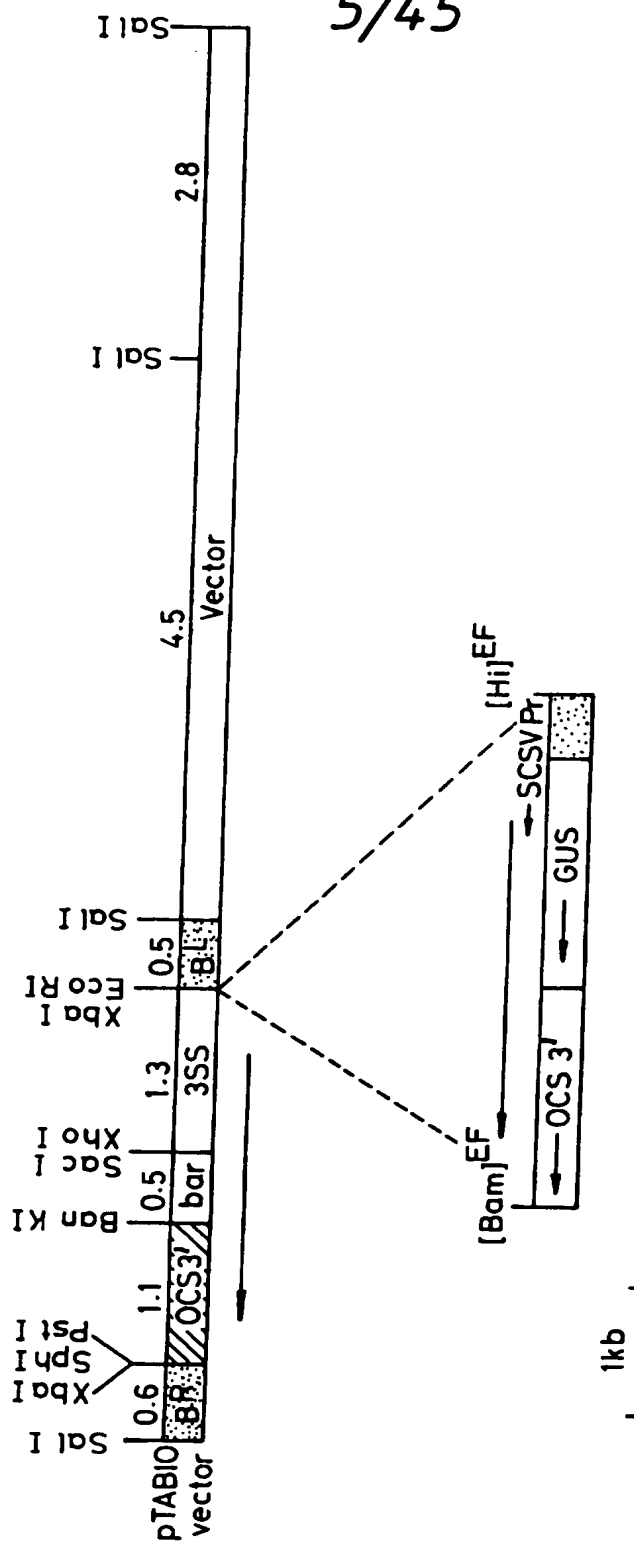


Fig. 5

6/45

COMPONENT 1

1 TAGTATTACC CCCGTGCCGG GATCAGAGAC
61 CCTTGGATTA AATGACACGT GGACGCTCAG
121 GAACGAATCT GACGGAAGAG CGTTCACACT
181 GTCTTGGGTC TATAAATAGA GTGCTTCTGA
241 GATTCTGGTG ATGGTTACAA TACATACTCA
301 GAAGTTTTAT ATAAAATAGG TATTATTATG
361 GTTTTAATTA TATTATGTTG TGCTGTTCCT
421 TTATCTTCGT CTTCTATTAT GAAGAGGAAG
481 GAAGAAACTG GTCCTCATCG TGAAAGAAGA
541 CAGAATAATA ATGATAATGT AAATAGATTT
601 ATGAGAATTA TTATTATTCT GTTCTTCGTC
661 TGGCGTCTGG AGAGAGAAAG GAATAATTGT
721 TGTCTTTACT TCGCCTCGAA GAAAGACACA
781 GAAGCTTCCT CGAAGCAGCG TATAACTTTA
841 ATTGCGGCTG TAAACGTGTC AAGTTGTGAG
901 ATTGTTTTAA TTTAATTCCG CGAAGCGATA
961 GATGACGTCA TATGTCTCCG TGCCTACGTC

Fig. 6

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COMPONENT 1 (cont.)

ATTTGACCAA TAGTTGACTA GTATAATAGC	60
GATCTGTGAT GCTAGTGAAG CGCTTAAGCT	120
TAGATCTAGT TAGCGTACTT AGTACGCGTT	180
ACAGATTGTT CAGAATTTCA TAGCGAGATG	240
TATGAAGAAG GTGCTGGAGA TGCGAAGAAG	300
TTATGTATTG TAGGGATTGT AGTTTTATGG	360
CGCTATGCTA AATCAACGAT GGACGCTTGG	420
ATGGCTTCAA GGATTACTGG TACTCCGTTT	480
TGGGCTGAAA GAAGAACTGA AGCGACGAAC	540
AGTTGATATG TTGTAATTTT ATATGGATTA	600
TGTGTTTTTT AAGCTTTTTC TGTGTTTAA	660
AAGGTAGACG ACGATGTAGT GGATTACAGT	720
TTTCAAGTTG TGAGTGTTAT TGCTTTTGAG	780
ATTTGAATTT GGTTTTGGCG CGTTAGTGAA	840
TGGCTGAAAT AAGATAATAG ATATATTATT	900
TGTTAAGTGA TAAATGAAAC GAAGCGTTTT	960
AGCACGGGGC T	1001

Fig. 6(cont.)

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COMPONENT 2

1 TAGTATTACC CGACCTTGCC ACACCTCCTT
61 ACTTTCTCTC TCTAAGCTTA TATGGCTAGA
121 GAGATAGAGA GAGAAACATT CCTCTCCCTC
181 GTCGGCGACG AAAGTGAAC TACTGGACAG
241 AACAAAATTC GTCTTGGTGG ATTGAAGAAG
301 GCGAGAGGCA GCGATTCTCA GAATCGCGAT
361 ATTGGGATTC CGGTCATGAA GGGTTCGAAC
421 GATCCCGAAG AAATGCAATT GAAGGATCCA
481 TTGAAAGAGG AATATTGTTC CTGTTATGAT
541 CTTACAGAGG ATTTAATGGC GGAACCAGAT
601 GACGGAGGAG AAGGAAAGAC GAGCTTCGCG
661 ACAGCCGGAG GGAAGACCCA GGACGTATTA
721 ATTGCGTTTG ATGTTCCCAG GTGTTCTTCG
781 TTGAAGAACA GAGTTTTTGC AAGTACAAAA
841 TTAGTTCATT TAATTGTGTT TGCCAACGTG
901 AGACTTGTA TATCAATTG TTGAATAAAA
961 GCGAAGCGGT AGCCGGTCAT AACACTGTTG
1021 CT

Fig. 6(cont.)

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COMPONENT 2 (cont.)

GGAACACTTT CTCTCTCTAG AAAGTGTGAG	60
AGGTACTGTT TTACATTAAA TTACGCTACT	120
TTCTCTCAAG ACGAATTAAA CTATTTCGTT	180
AAACACCTCC AGGGATTTGT ATCGTTCAAG	240
AAATTTGGTA ATCGAGCTCA CTGGGAAATT	300
TATTGCTGTA AAGAAACCCT AATTTCTGAA	360
AAGCGGAAGA CGATGGAGAT TTATGAAGAG	420
GATACTGCTC TTCGATGTAA GCGGAAGAAA	480
TTTCAGAAAC TCCGTCCATG GCAAATTGAG	540
AAGGAATTAA TCAGGTATGG ATGGTTTTAT	660
TATATGTATG CTCAAGACCC AGAGAGGAAT	720
GAGATGATGA ACTATCAGGC GATGGAGATG	780
TATAGGCCTG TAGATCTTTG TATTAGGAAG	840
GCACCTGACC CCACGCGCAT AAGTGAGGAC	900
GAATATATAT TATTGTTTTA ATTTAATTCC	960
CCCTTGGAAC ACTATATATA GCAAGGTCGG	1020
	1022

Fig. 6(cont.)

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COMPONENT 3

1 TAGTATTACC CCCGTGCCGG GATCAGAGAC
61 CCCTTGGATT AGATGACACG TGGACGCTCA
121 TGAACGAATC TGACGGAAGA GCGGACATAC
181 TGTATCTCTT TACAGCTATA TTGATGTGAC
241 GTAGGAAATT GCTCGCTAAG TTATTCTTTT
301 ATTAAATGAG TGGCTATAAA TAGATGTTTC
361 TCTTGTGTTA ATGGCGTTAA GGTATTTCTC
421 TATGAACGAG CACTTGAAGG AAATTAAGAA
481 TGCGTGTGCT GTGTTCTGAAG GTTTAACAAA
541 ACGCTTCTCT GGGTTTCTGG AAGGTCTGTC
601 GTGTTTAGTT AGATGGAAGA AGAGCGTTGC
661 GATGCATTAC AAGCTTTATG GATTTCAGAA
721 GTTTCCTAAT TACGGTGAAG ACGATGTAGC
781 GCAATTAGAA GTTGTATTTG ATGATTTAGG
841 AGGTTCTATT AAGATAGAAT TATGAGATGT
901 TATTCTTTGA ATTACTCCGC GAAGCGGTGT
961 ATATGTCTCG CCGACAGGCT GGCACGGGGC

Fig. 6 (cont.)

11/45

COMPONENT 3 (cont.)

ATTTGACCAA TAGTTGACTA TGAATAATAG	60
GGATCTGTGA TGCTAGTGAA GCGCTTAAGC	120
GCACATGGAT TATGGCCAC ATGTCTAAAG	180
GTAAGATGCT TTAATTTCGCC TCGAAGTAAA	240
CTGAAAGAAA TTAATTTAAT TCTAAATTAA	300
GTCTTCGTTG TTTTACAACG AAGCTTAGAA	360
TCATCTTCCT GAAGAACTGA AGGAGAAGAT	420
GAAGGAATTT CTAGAGAATG TAATTAAAGC	480
GAAGGAGTCT GTTGAAGAAG ACGACATACT	540
TGCATATTAT GCAGAGGCCGA CGAAGAAGAA	600
AATAAATCTG AAATGGAGAG TTATGGAGGA	660
CATGGAAGAT TTATATTATT CAGAGTTAGG	720
TTATCACGAT GGTGCAATTG TAAATTGTAA	780
TATTGAGTTT ATGTCTATTG TAATTGATAG	840
AATTGTGATT AATGAATAAA GAGTTGTTAT	900
GTTATGTTTT TGTTGGAGAC ATATGACGTC	960
T	991

Fig. 6(cont.)

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COMPONENT 4

1 TAGTATTACC CCGTGCCGGG ATCAGAGACA
61 CCTTGGATTA GATGACACGT GGACGCTCAG
121 GAACGAATCT GACGGAAGAG CGGACAAACG
181 AGAAGTGAAT GACAGCTGTC TTTGCTTCAA
241 AAGAATAAGC GTACTCAGTA CGCTTCGTGG
301 GTTGTATCAT CAACGAAGAA GTTAAGCTTT
361 CAGTGCGCTT AAGACATGTA CTCATGTCTG
421 ACAGGATTTC TTCTGTTGTG ATAGTATGCC
481 GTTAGTTAGT TGTTTTGTAA GTTTTACTGG
541 AGGTCAAGTT CAGTTGGGTA TGCAGCAAGA
601 TCCTATTGGG GGTTATTTGT ATCATGATGA
661 CAATCTGGAC ATCGAGTCAG ATTATCTGAA
721 AATTAATATT GTAAATGATA AAGGATTAGA
781 TCATACGATG CGTATTAAGG TGTAATTGTT
841 GTGTTATTTG GTAATTTATG CTTATAAGTA
901 TAATGAGGAT AATAATTGAA TTTGATTAAA
961 TGAGAGTCAC GTGATGTCTC CGCGACAGGC

Fig. 6(cont.)

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COMPONENT 4 (cont.)

TTTGACTAAA TGTGACTTG GAATAATAGC	60
GATCTGTGAT GCTAGTGAAG CGCTTAAGCT	120
CACATGGACT ATGGCCCACT GCTTTATTAA	180
GACGAAGTAA AGAATAGTGG AAAACGCGTA	240
CTTTATAAAT AGTGCTTCGT CTTATTCTTC	300
GTTCTGCGTT TTAATGGCGG ACTGGTTTCA	360
TGATTTTTCA GATATTAAGG CGTCTTCACA	420
AGGTAAATTA TCTGAACCTA GGAAGGTGTT	480
TAGTTTTTAT GGAAGTAATA GGAATGTTAG	540
TGATGGCGTT GTTCGTCCAA TAGGATATAT	600
TTATGGATAT TATCAAGGAG AGAAGACGTT	660
GCCTGATGAA GATTTTTTGA AGAGATTAC	720
TGATAGGTGT GATGTAAAAT GTTATGTAGT	780
ATTATCAATA AAAGAATTTT TATTGTTATT	840
ATTCTATGAT TAATTGTGAA TTAATAAGAC	900
TTAACTCTGC GAAGCTATAT GTCTTTCACG	960
TGGCACGGGG CT	1002

Fig. 6(cont.)

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COMPONENT 5

1 TAGTATTACC CCGTGCCGGG GTCAGAGACA
61 CCTTGGATTA GATGACACGT GGACGCTCAG
121 GAACGAATCT GACGGAAGAG CGTCATGGTC
181 GTATTGATTT GACTTTACGC GCTTTACTTT
241 TTTGCTCGCG ACGAAGCAAA GTGATTGTAG
301 AACACGGTTT GATTGTGGGT ATAAATATGT
361 ACGAAGATGG TTGCTGTTCG ATGGGGAAGA
421 TCGCGAATTG CTTACAAACC TCCTTCGTCT
481 AATAAGAGAG ATGTTACTGG AGCGGAGGTT
541 ATGAAGAAGG TAATGTTGAT TGCAACATTA
601 CTTATTGTGA AGAGTAATTC GCCTATTGCG
661 TTGATGGTGA AAGAGTCTGT TCAAGATACA
721 TCTTCTGGTA CTGCTGGTAA AGATGTA ACT
781 TCAGGTATTA GTCAGACCCA GCATTTGTAT
841 ATCACACTGG AGACGAGAAT GTATATTGAT
901 TTGTTTTTAT TCTTTGAATT ACTCCGCGAA
961 TGACGTCATA TGTCTCCGCG ACAGGCTGGC

Fig. 6 (cont.)

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COMPONENT 5 (cont.)

TTTGA	CTAAA	TATTG	ACTTG	GAATA	ATAGC	60
GATCT	GTGAT	GCTAG	TGAAG	CGCTT	AAGCT	120
CACAT	GTCTA	AAGA	ATAATG	CTTTA	CAGCT	180
AATTG	CTTTA	AGTAA	AGTAA	GATG	CTTTAC	240
CTGC	A	AAAT	TGATG	CTTTA	ATTACCGGGT	300
TCTGT	TCGTT	TTCTT	CGTTG	TCATTT	TACA	360
AAGGG	TCTGA	GGTCT	CAAAG	GAGAA	AATAT	420
AAGGT	TGTAA	GTCAT	GTGGA	GTCTG	TTCTG	480
AAGCC	ATTCTG	CTGAT	GGTTC	AAGGT	ATAGT	540
ACTAT	GGCTC	CTGG	A	AATT	ATTAT	600
AATTG	GAGTT	CGTCT	TTTCAG	TAATC	CCTTCG	660
GTTAC	GATTG	TTGG	A	AGCT	TGAG	720
AAGT	CTTTTA	GGAAG	TTTGT	TAAG	CTGGGT	780
TTAAT	TATTT	ATTCC	AGTGA	TGCG	ATGAAG	840
GTATA	AATTGT	GATGA	TTAAT	GAATA	AAGAG	900
GCGGT	GTGTT	ATGTT	TTTTTGT	TGGAG	ACATA	960
ACGGG	GCT					998

Fig. 6(cont.)

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COMPONENT 6

1 CAGTATTACC GCACCTCGCT TACCCTCCTC
61 AAAGCACTAG TTGGGTGTTC AACTTAACT
121 ATGAAAGCGT TCAGTACGCT TGTGCGCAGC
181 GATTTATACA ATTTAAATCC CGCAACACTA
241 GACTGAATCC TCATCTGGAA ATTGCTAGGG
301 AGGAAGATAG TAGAGTAGCT GGTCCCTGGG
361 ATAAGCGTAA GCTGATGGAG AGATTTGAAG
421 CCTCTCTCTA TAGGCGTTGT CTATCAAGGA
481 AGTGGAATTA TGACTTACGC CCTTGGCAAG
541 CAGATTATAG AACGATAATC TGGGTGTATG
601 TTGCAAGACA TCTGTCATTG AAAGATGGTT
661 ATATGATGCA TCTTGTGACT GCTGAGCCTA
721 TTAGTTCAGA GTATGTGAAT TATGGTGTAA
781 ATACTAAGTA TGAGCCATGT GTAATGCGGG
841 TTGCAAATGT ACTCCCAGAT TTGGGAAAAT
901 GTTGAAAACCT CTGCGAAGGC AGAAGTTATA
961 TCGGGTAGTT CGCGAAACAG GGTGAGGGAA

Fig. 6(cont.)

17/45

COMPONENT 6 (cont.)

GCTTCCCTGG	GCCCACTATG	CCTACTAGAC	60
TTGAGGGCGA	AATTCCTATT	TTGCCCTTTA	120
ATGAGAGAGT	GGGACACGAT	CATTTACAGG	180
CATTGCGTCA	GGCTAAGTAT	ATTTTAAATG	240
ATGTAGAGAA	GGCGCAATTG	TACGCGATGA	300
AGTATGGGTT	GTTTATTAAG	AGAGGATCGC	360
AAGATGGAGA	AGAGATGAAA	ATTGCTGATC	420
AGATGGCTGA	AGAACAACGT	TGTTCTTCTG	480
AAGAAGTGAT	GCATTTGTTA	GAGGAAGAAC	540
GACCTGCTGG	TAATGAAGGC	AAATCTACAT	600
GGGGTTATCT	GCCTGGAGGA	AAGACACAAG	660
AGAATAATTG	GGTATTTGAC	ATACCCAGAG	720
TAGAACAGGT	TAAGAATAGG	GTAATGGTGA	780
ATGATAATCA	TCCTGTTTCAT	GTAATTGTGT	840
TAAGTGAAGA	TAGAATAAAA	TTAATTCGTT	900
AAAAAAATGT	GTTTTGAGAG	AAGTCCCACA	960
GCGAGCAATA	TAAGGCGAGG	TGCGTAT	1017

Fig. 6 (cont.)

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COMPONENT 7

1 TAGTATTACC CCGTGCCGGG ATCAGAGACA
61 CCTTGGATTA GATGACACGT GGACGCTCAG
121 GAACGAATCT GACGGAAGAG CGGACATACG
181 GTATCTCTTT ACAGCTATAT TGATGTGACG
241 TAGGAAATTG CTCGCTAAGT TATTCTTTTC
301 TAAATGAGTG GCTATAAATA GTGTCGATGC
361 CTGTTCTGGT TTTAAGCGAT GGTCAGTTTT
421 GATGTTCTTG TAAGCGATAG CAGAAGAAGT
481 GTGATTAACG TGAAGGTACT GAGGTTGATT
541 AAGGTTATGT TTCGTCTGTG TTACAGATAC
601 TGTAAGATGG AGCTATGGAC TTCGTTGAAG
661 TTGCAGAGGA AGCTTAATGG TATATGTGTT
721 GTAAGTAATG TTAAAGAGTT GATTAATAGA
781 AATCCTATAT GTTGTTTGTA TCATATGGAC
841 TATGAGATAA GAGTTGTTAT TAATGCTTAT
901 TTTTATTCGC GAAGCGGTGT GTTATGTTTT

Fig. 6(cont.)

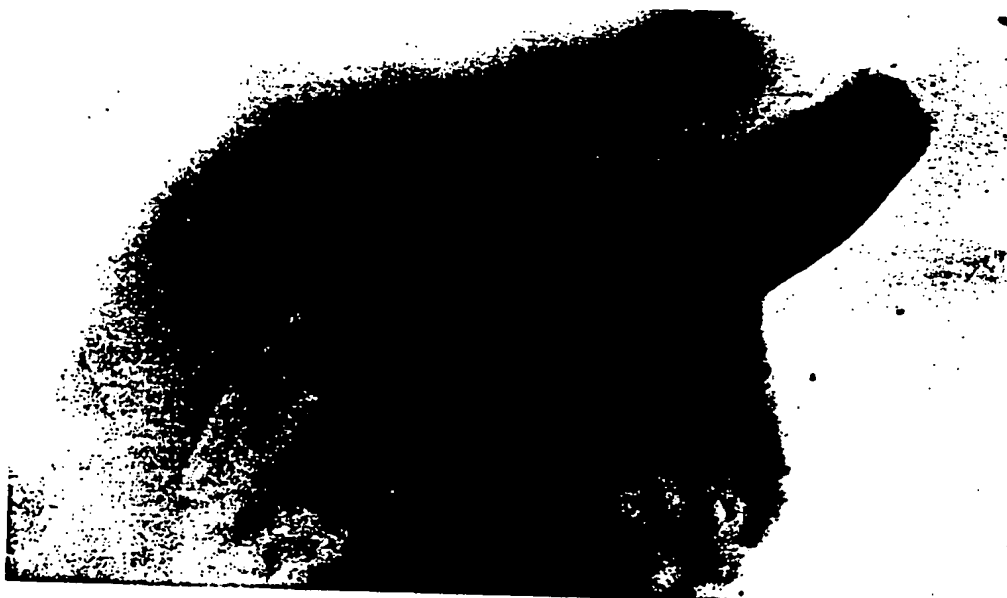
19/45

COMPONENT 7 (cont.)

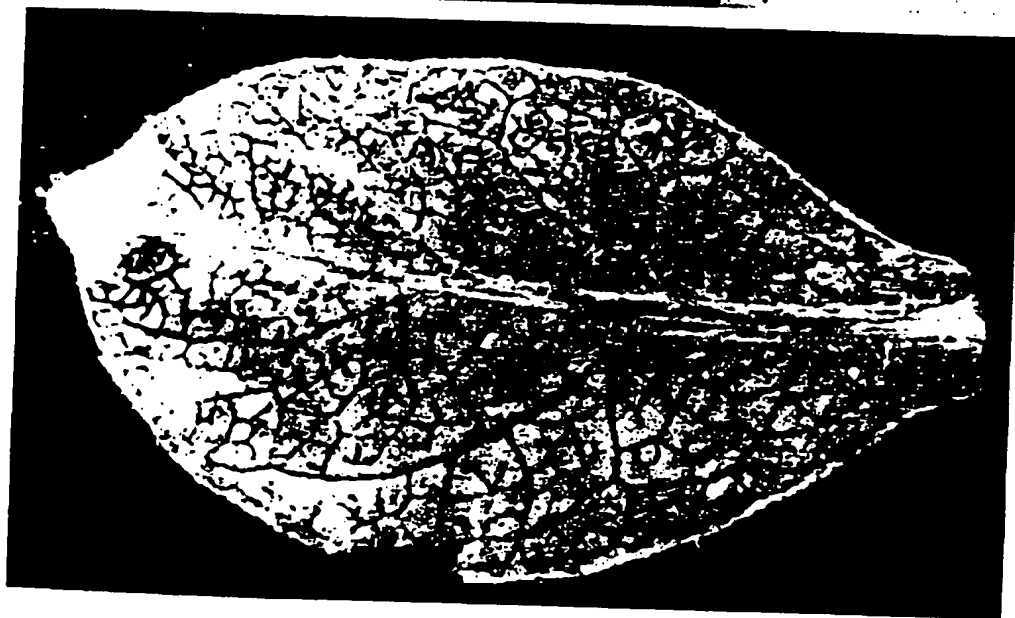
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TGAAAGAAAT TAATTTAATT CTAATTAAAT	300
TGCCTCACAT CGTATTCTTC TTCGCATCGT	360
AGTTTTCTTG AGATATACGA TGTGAGCGAC	420
GTAGCTGTTG AGGTCGAAGA GAAGGTTCAA	480
GAAGCTGTTG ATGAAGATAG AGTTGGAGTG	540
AGACGAGAAC TGAAGATTAC GTTGTTGGGT	600
TCTTCAGGCA AGTATTCAGT TCAATCTTTG	660
AGTAATTACT GTATAGGTAT TGATATGTTT	720
TGTAAATGGA TTACATCTGT TCAAGGTGTT	780
GAAGAGTAAT TAATAGTAAT TATGATTAAT	840
GAGGAATAAA GAATGATTAA TATTGTTTAA	900
TGTTGGAGAC ATCACGTGAC TCTCACGTGA	960
TGTCTCCGCG ACAGGCTGGC ACGGGGCT	988

Fig. 6 (cont.)

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Subterranean Clover



Tobacco

Fig. 7

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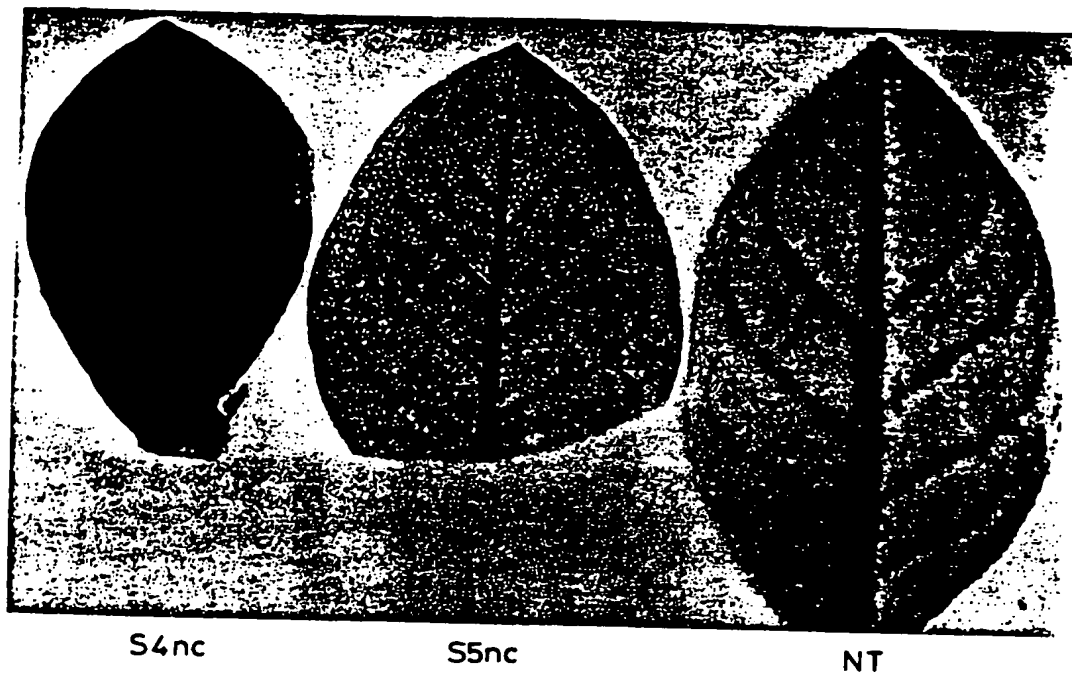


Fig. 8a

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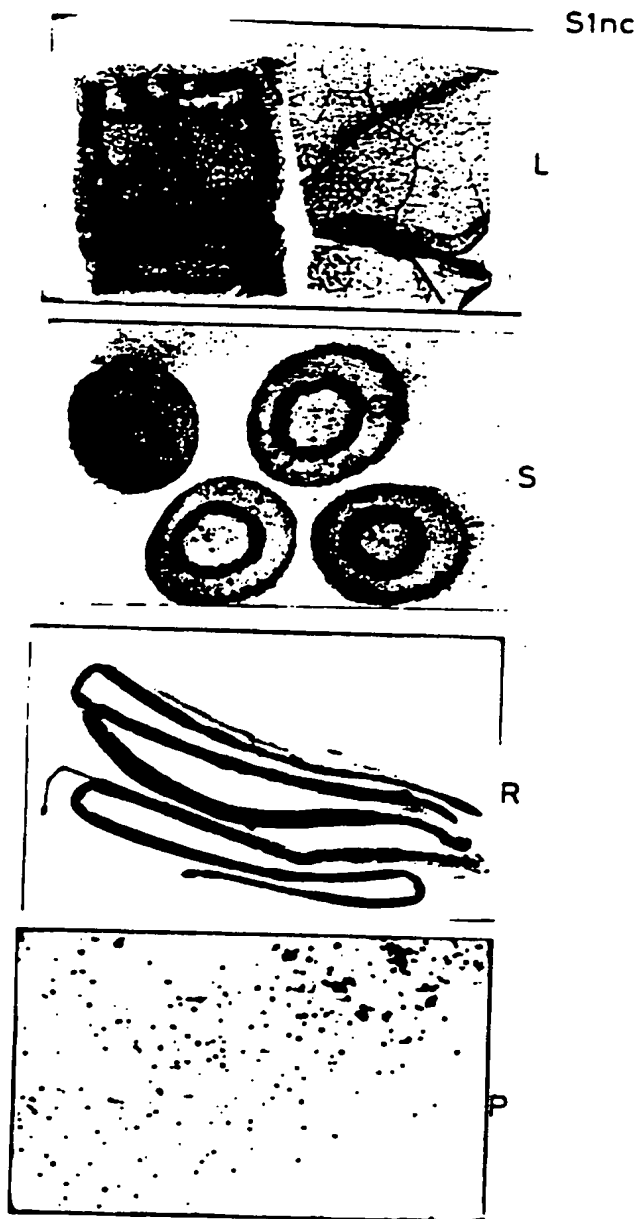


Fig. 8b

23/45

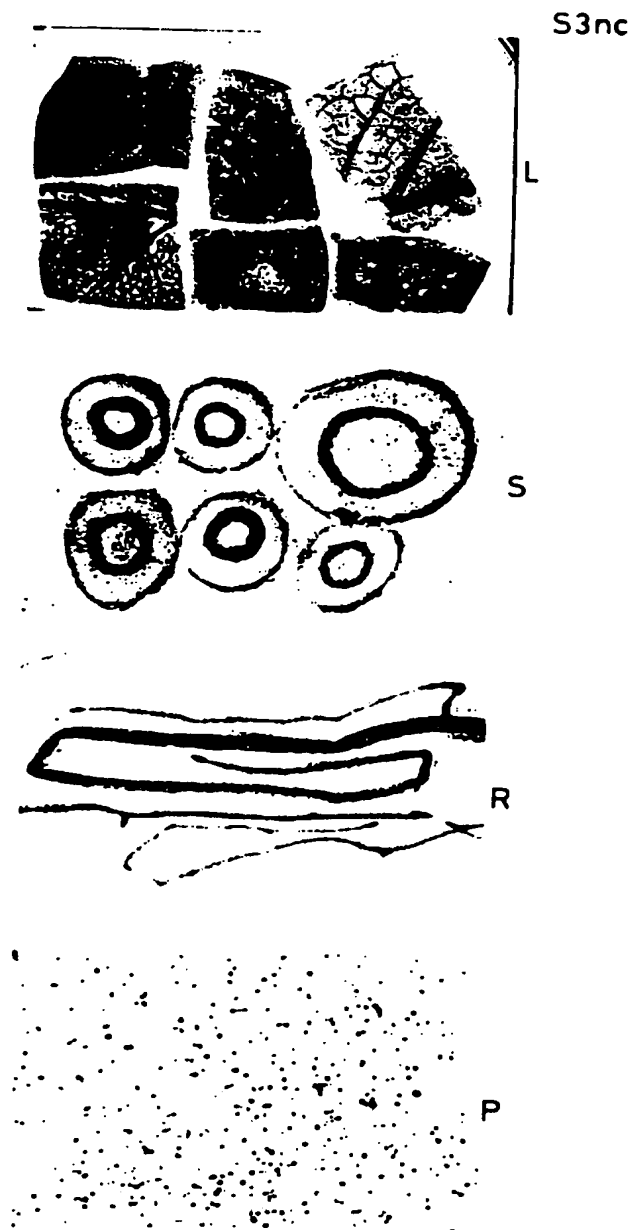


Fig. 8c

24/45

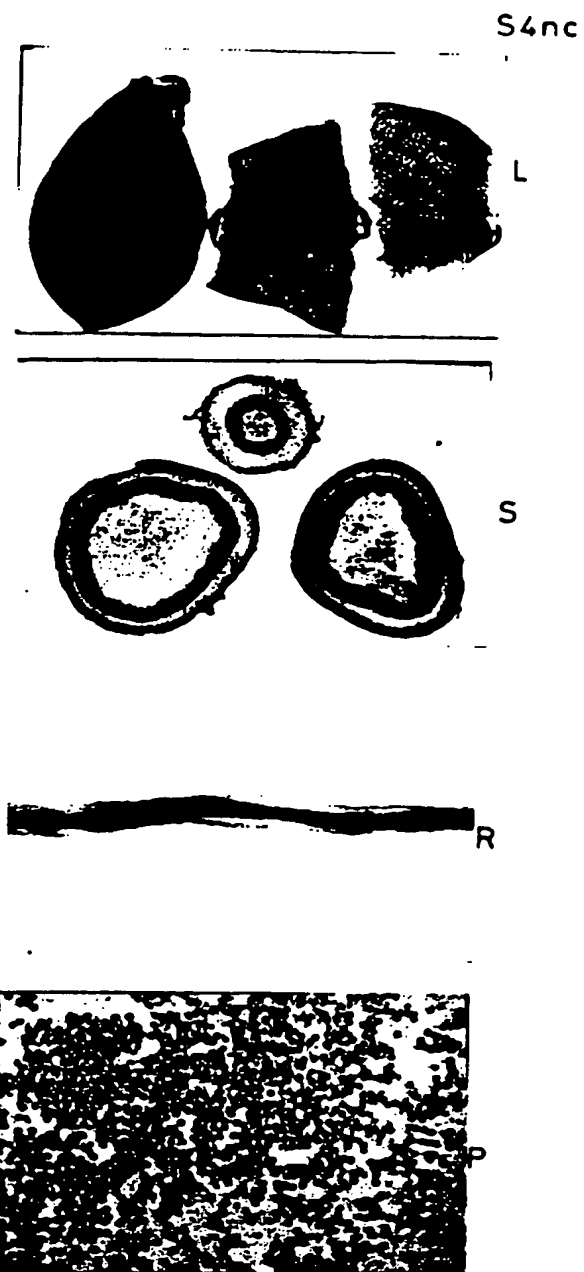


Fig. 8d

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S5nc

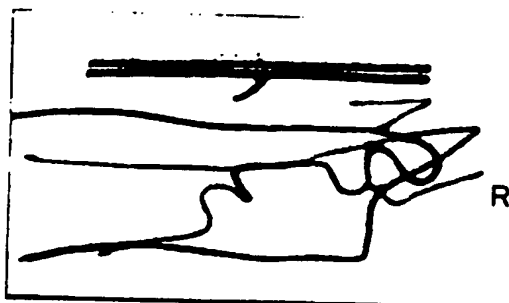
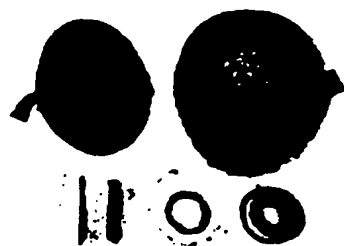


Fig. 8e

26/45

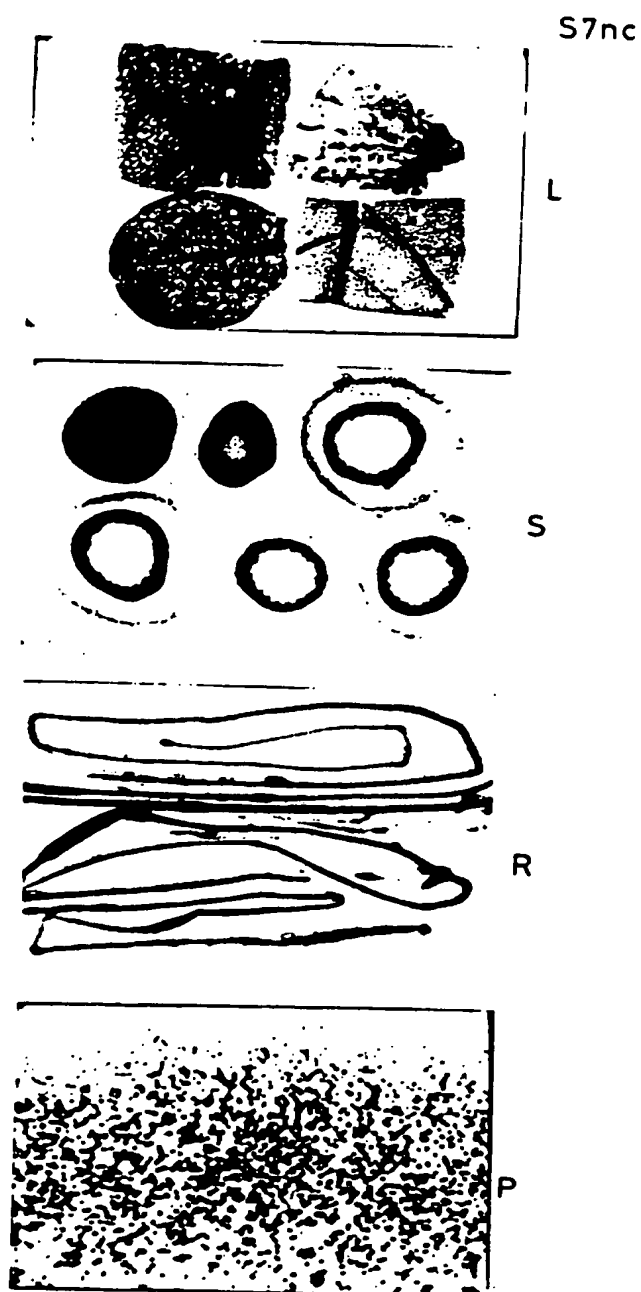


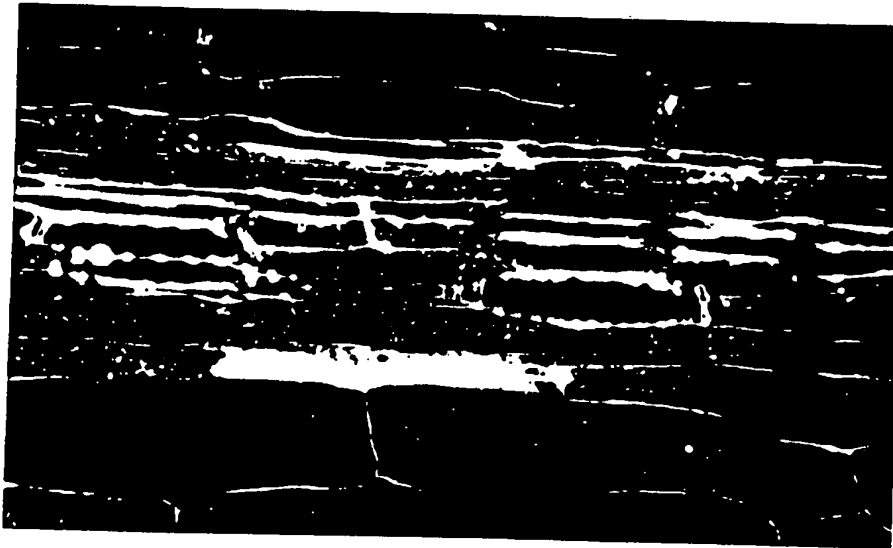
Fig.8f

27/45

S1nc



T

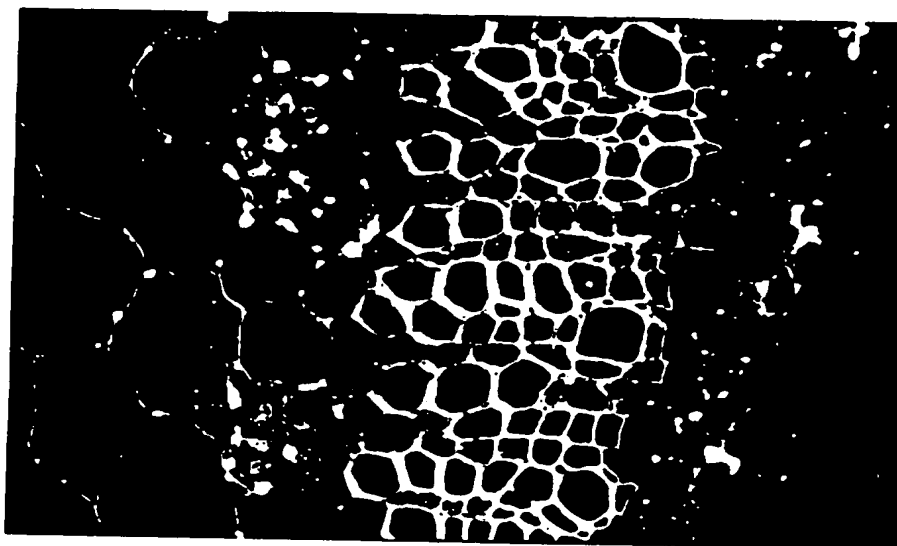


L

Fig. 9a

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S3nc



T

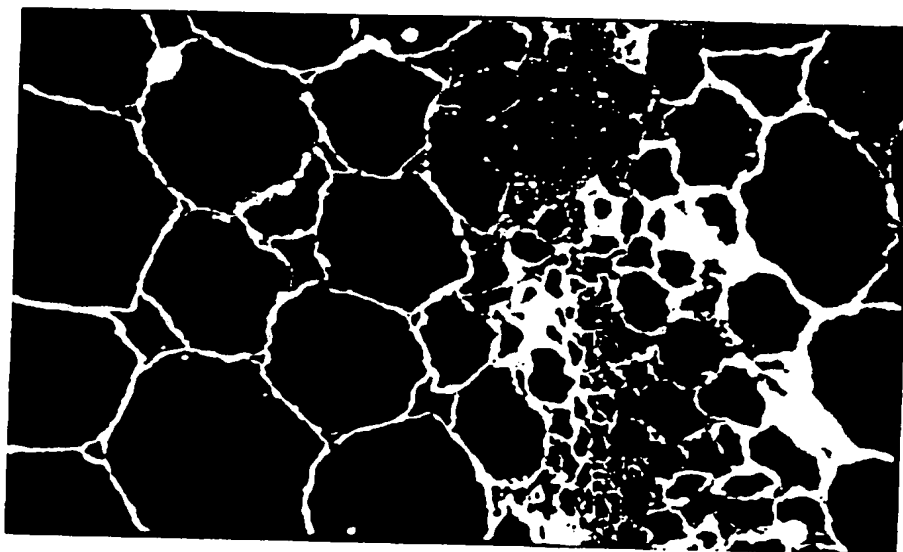


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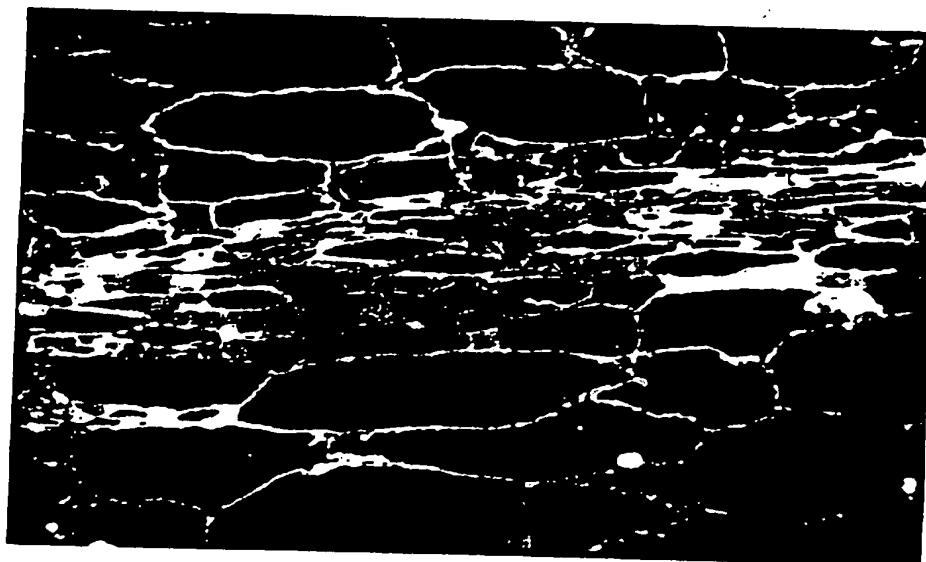
Fig. 9b

29/45

S4nc



T



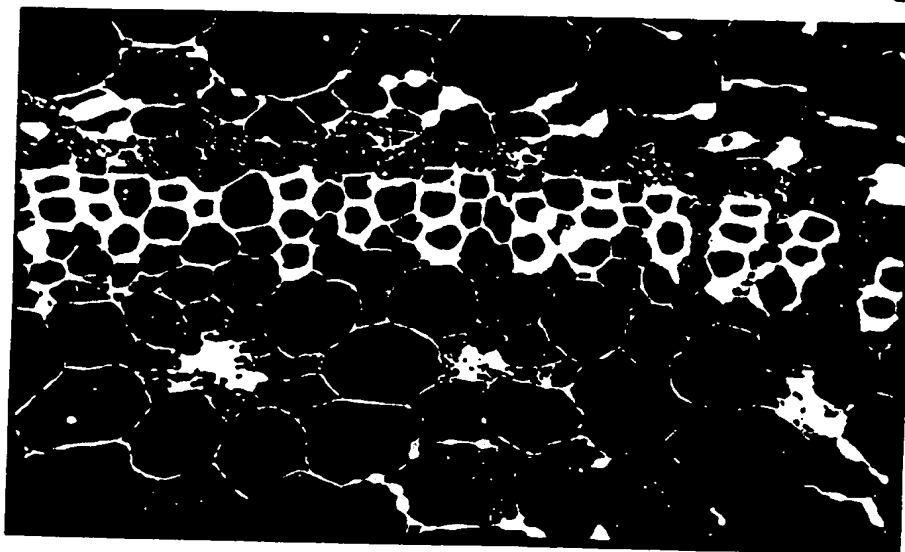
L

Fig. 9c

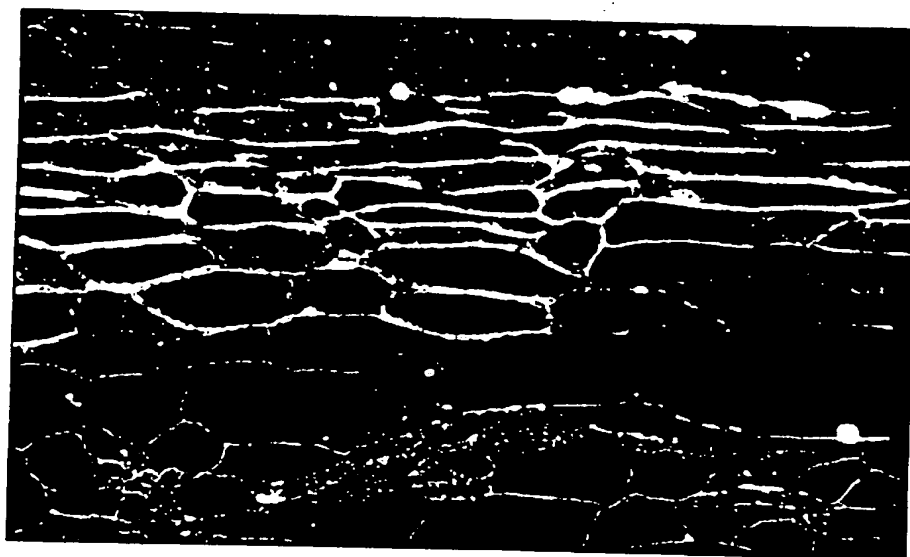
SUBSTITUTE SHEET (RULE 26)

30/45

S5nc



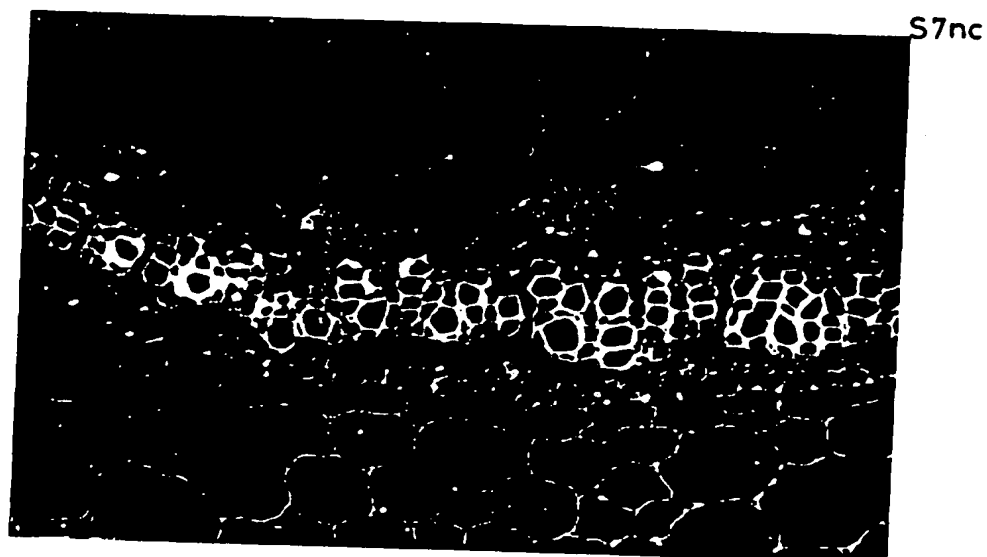
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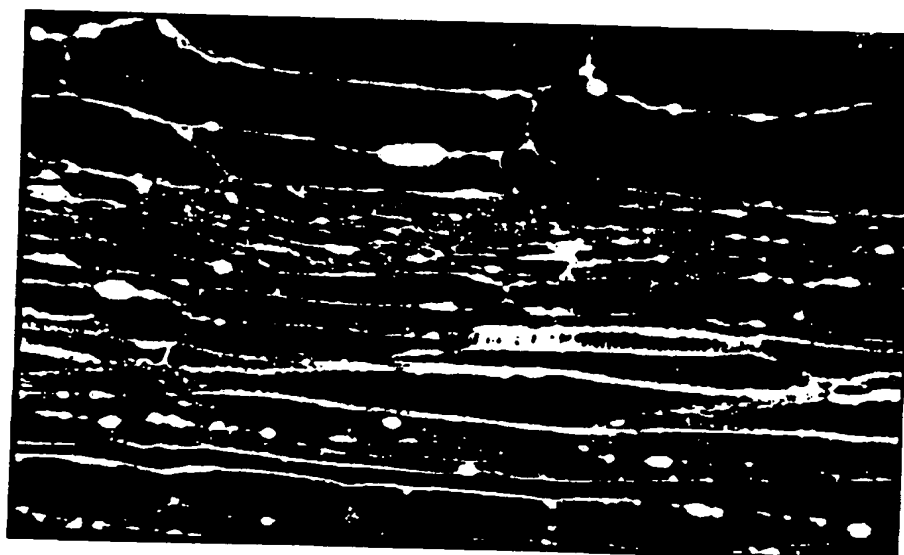
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Fig. 9d

31/45



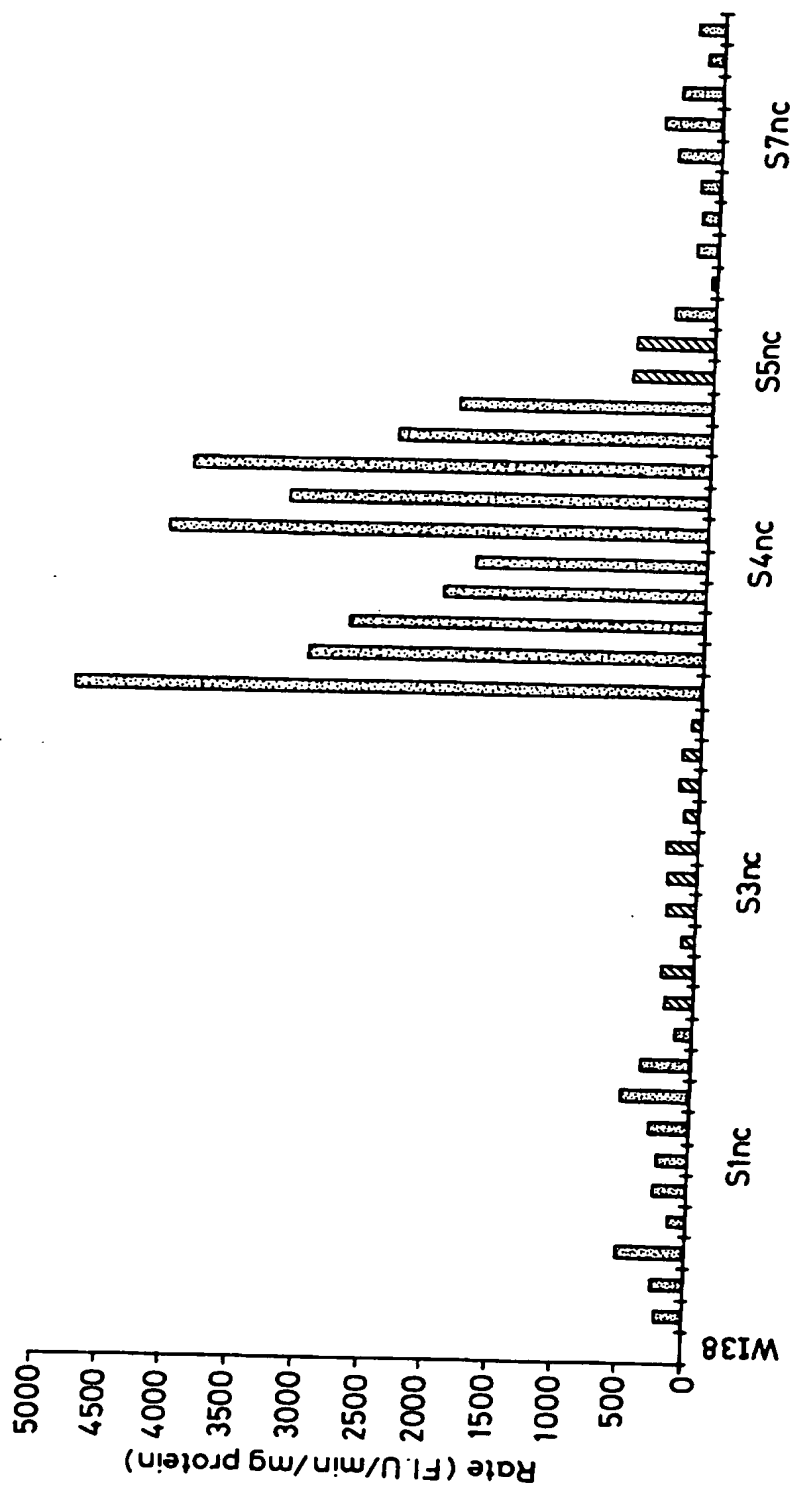
S7nc



L

Fig. 9e

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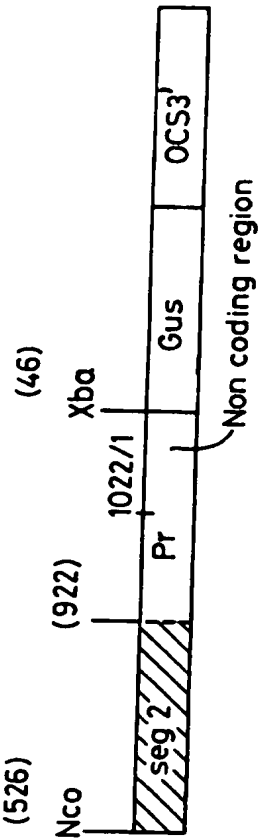


Fig.11

SC3Tr

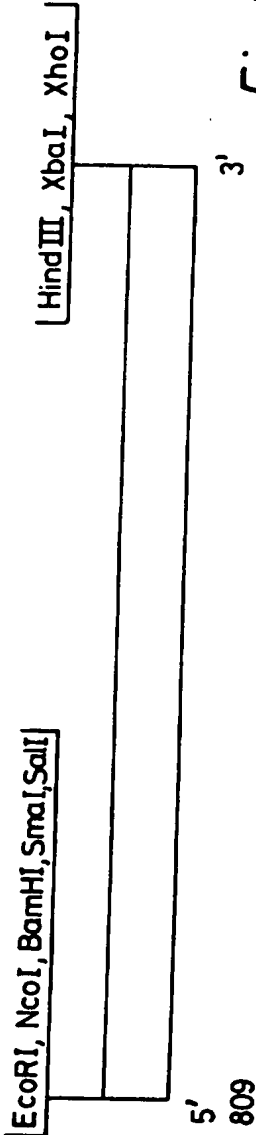


Fig.12a

SC5Tr

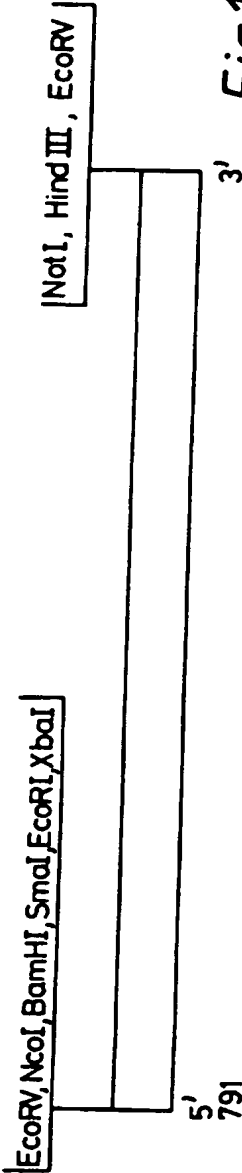


Fig.12b

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Fig.13a

Stem

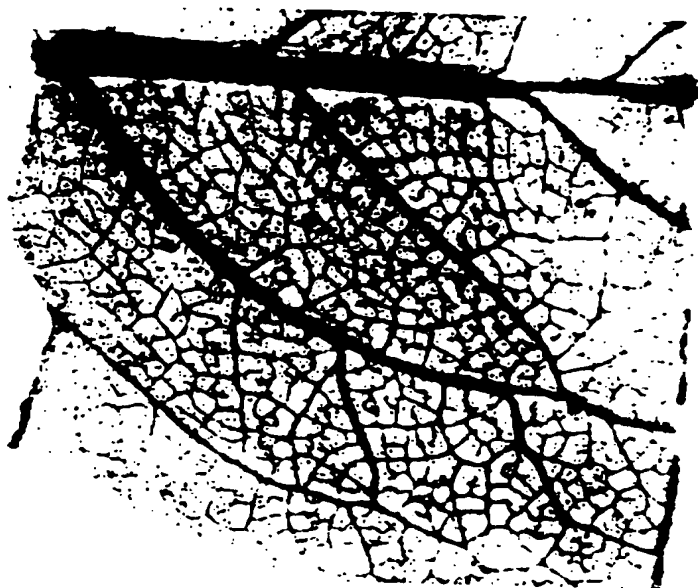


Fig.13b

Leaf

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Fig.13c

Stolon



Fig.13d

Tuber

36/45



Fig. 14

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1 TAAGTTTAGC GGGGGAAAAA GGACAGTTGA
61 ATGTTGTCAG ATGCATGTTG TAATGCTTGT
121 TGATGATGGA AACTTAAAGC TTAATACTAC
181 GGTTCTTTGT TTATCAGGAA TGCTCATTTGT
241 TATTGCCCTA AATCTGGTAC TTTATCCAAA
301 TCAAGAATGA TAAACTCGTA CACTCTCTAG
361 AACCGCTTAG GAAGGAACAT ATGTGATAAG
421 AGTCGGCCCA ATTCGAGAGG ACTAGTCTCC
481 TAAACAAAAC ACATATAAAA AACCTAAAAA
541 GTGGGAACAG TTACAAATCT GCAGTCTCAC
601 CAAGTTTTCG AATGTTCTCC CACCATTAC
661 TAGCTGACAC AACCCGTTTT GACCCAACAT
721 AATCGACTTG TCCTCAAGTC GAAAGGAGGG
781 ATTGGAGGTT GATGGATGAT TTCCTTGTGT
841 GCTTTTAATG CCTCTTGAAC TGTAGCCACA
901 AATTC

Fig.15

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TCTGTTGCTG TTTGCAATTT TTAAAGGGT	60
TCATCAACAC ATTATATGAC TTGCAGTTGC	120
TTTTGTTTAT TCACTTACAA ATACCGGTTG	180
ATGTAGCTAA AAGCTGGCCG TTTATAGTTT	240
AACTAAATTT GGAAACATCA AATACTTTTT	300
GGTACTCCTG AAATTTAAAT CAAAATCCAA	360
AACTGAAATT TCGATTA ACT ATTACAAGAT	420
GATTACAAGG AGTAAATATC TTAATCTTGA	480
TATAGGAACA TAATACATAA ACTAAAAGTT	540
TCCCTAAATT TGTGAGTCAC CTTTCACCTA	600
TTTCCCTCCA CCCGGATTCC CTCCAATTAA	660
TGGGTTCGTA TCAATACATC CGGCCCCGGAA	720
GAATTATTGT GCCAAGCAAA AAGCCATTCG	780
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	905

Fig.15 (cont.)

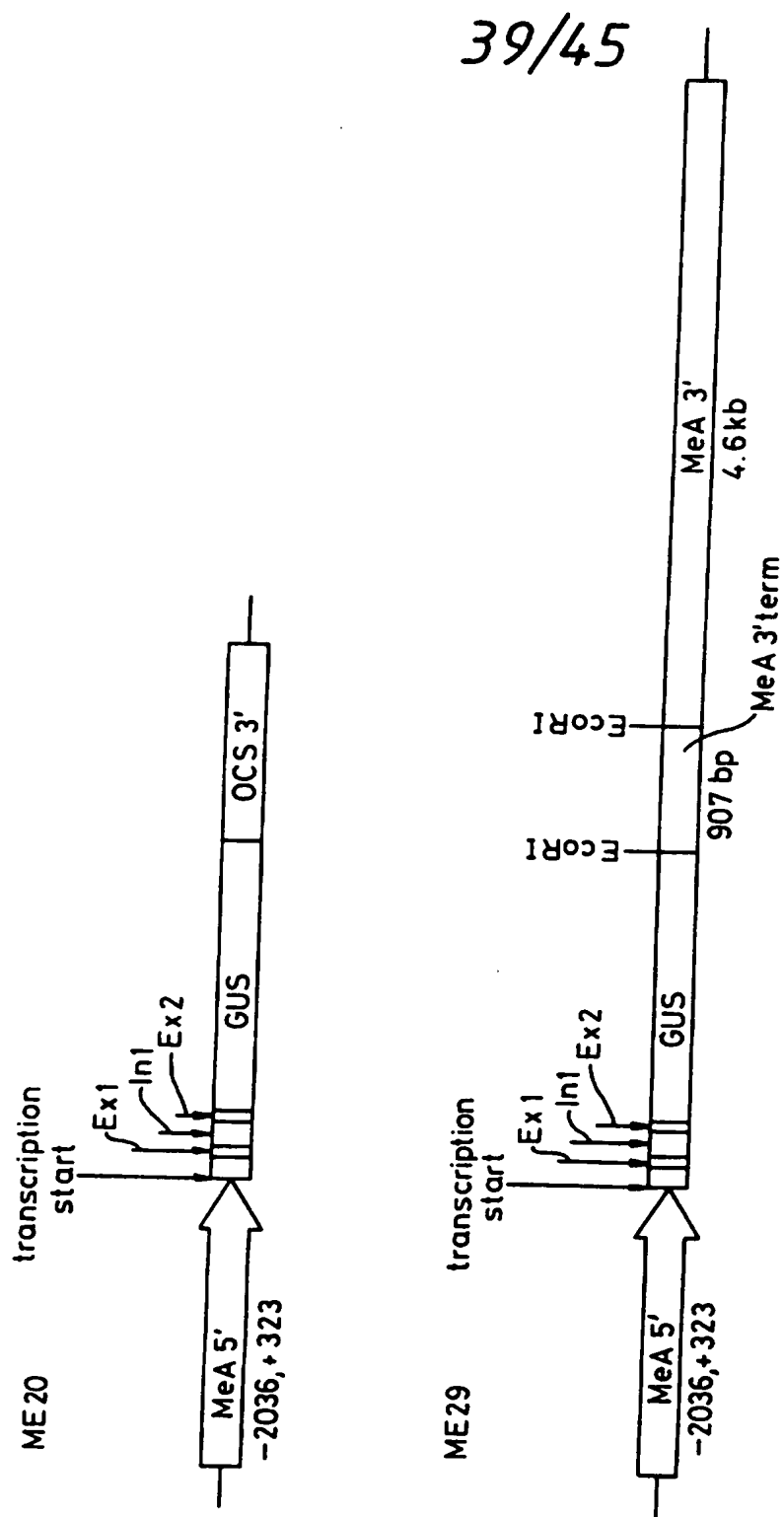


Fig.16

40/45

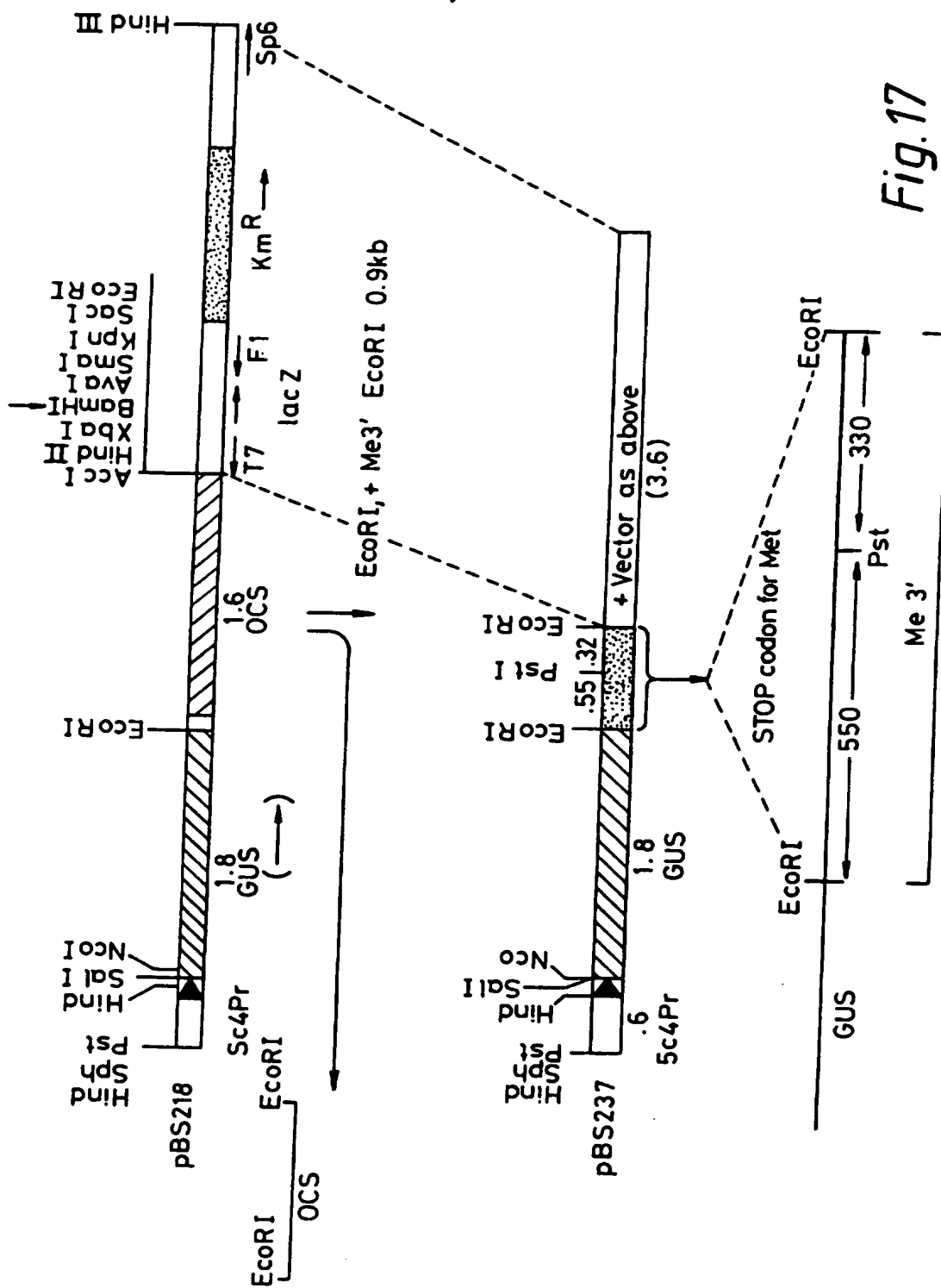


Fig.17

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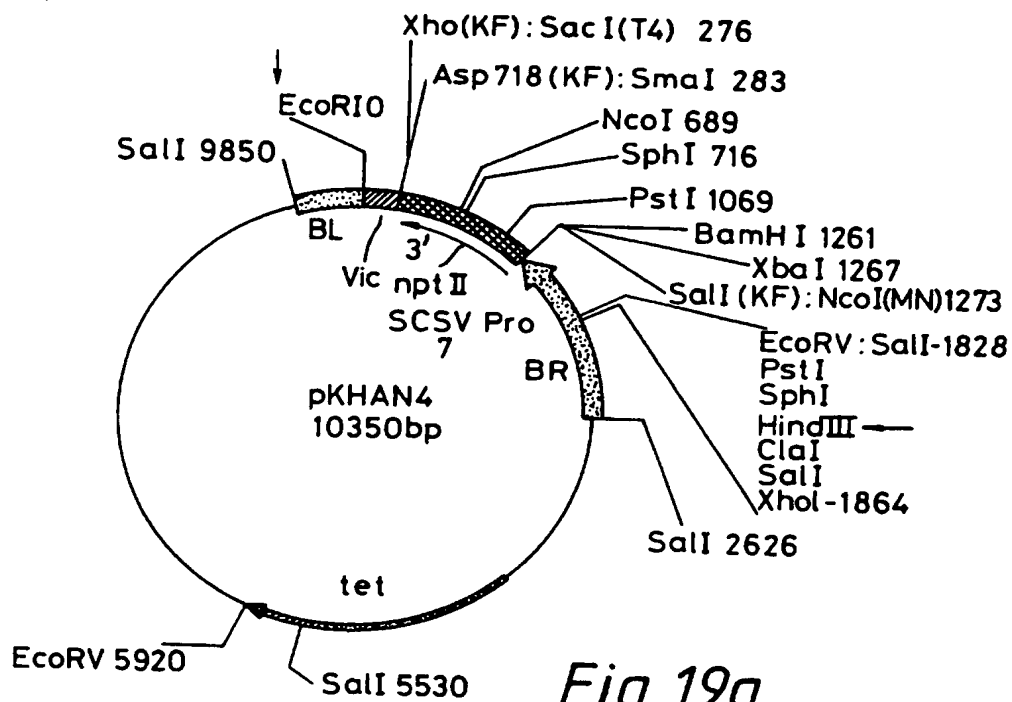


Fig. 19a

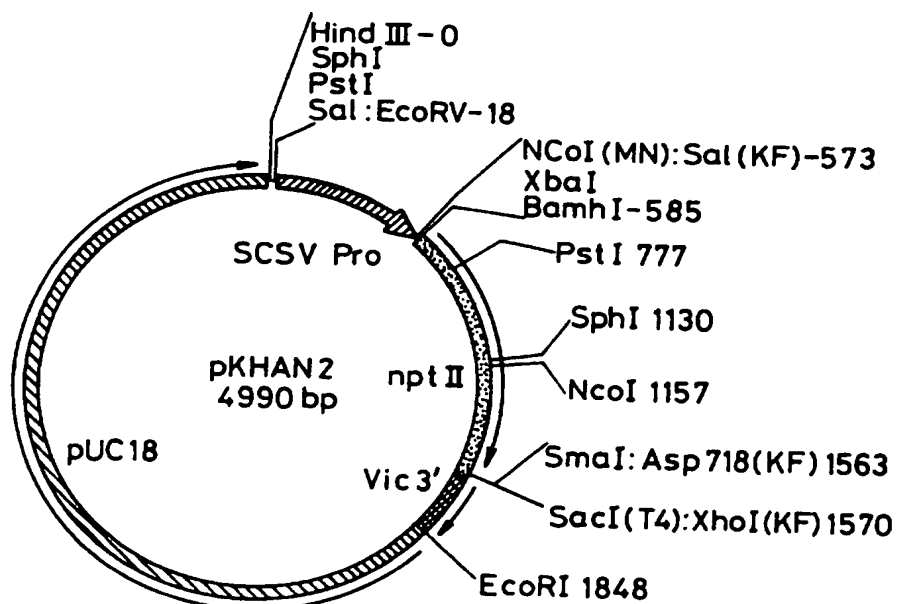


Fig. 19b

43/45

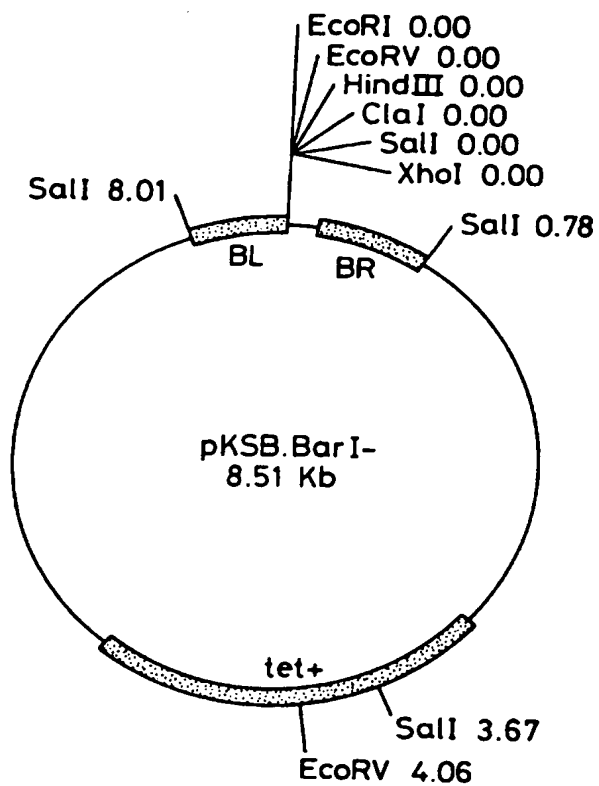


Fig. 19c

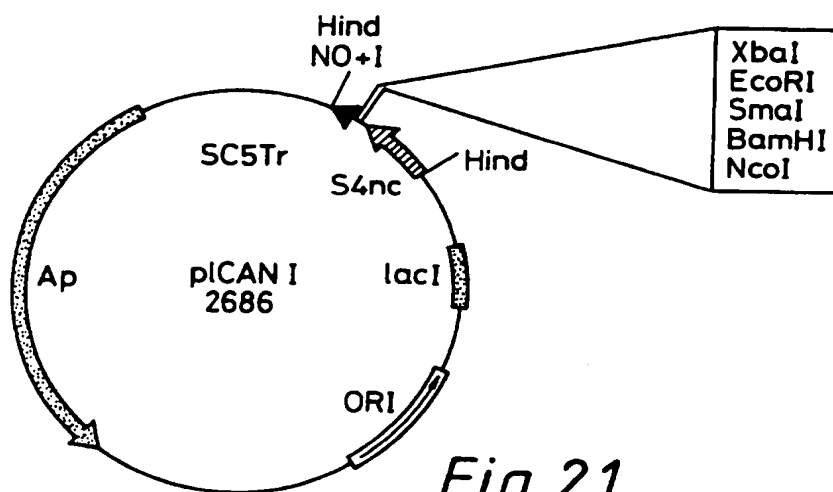


Fig. 21

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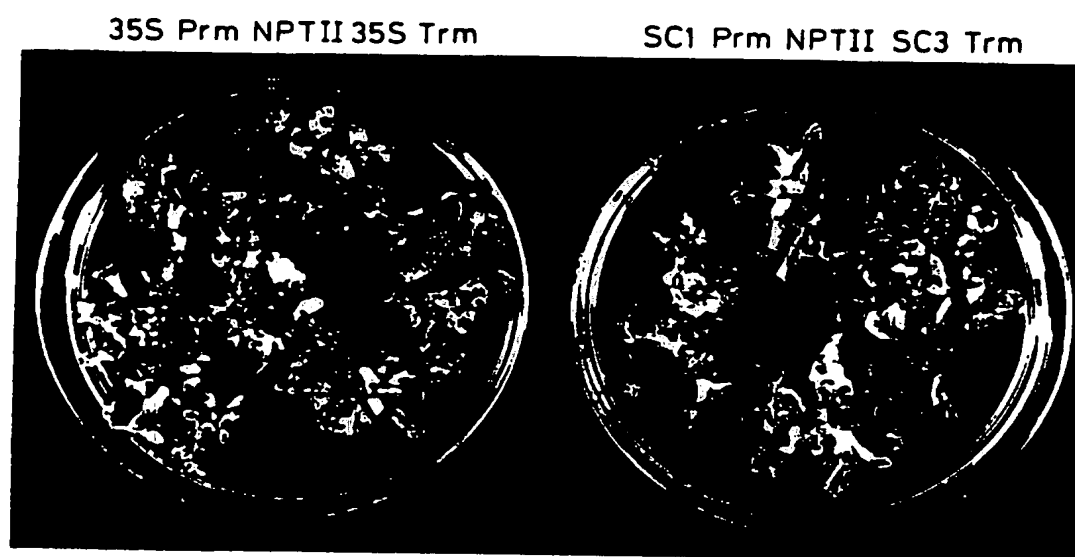
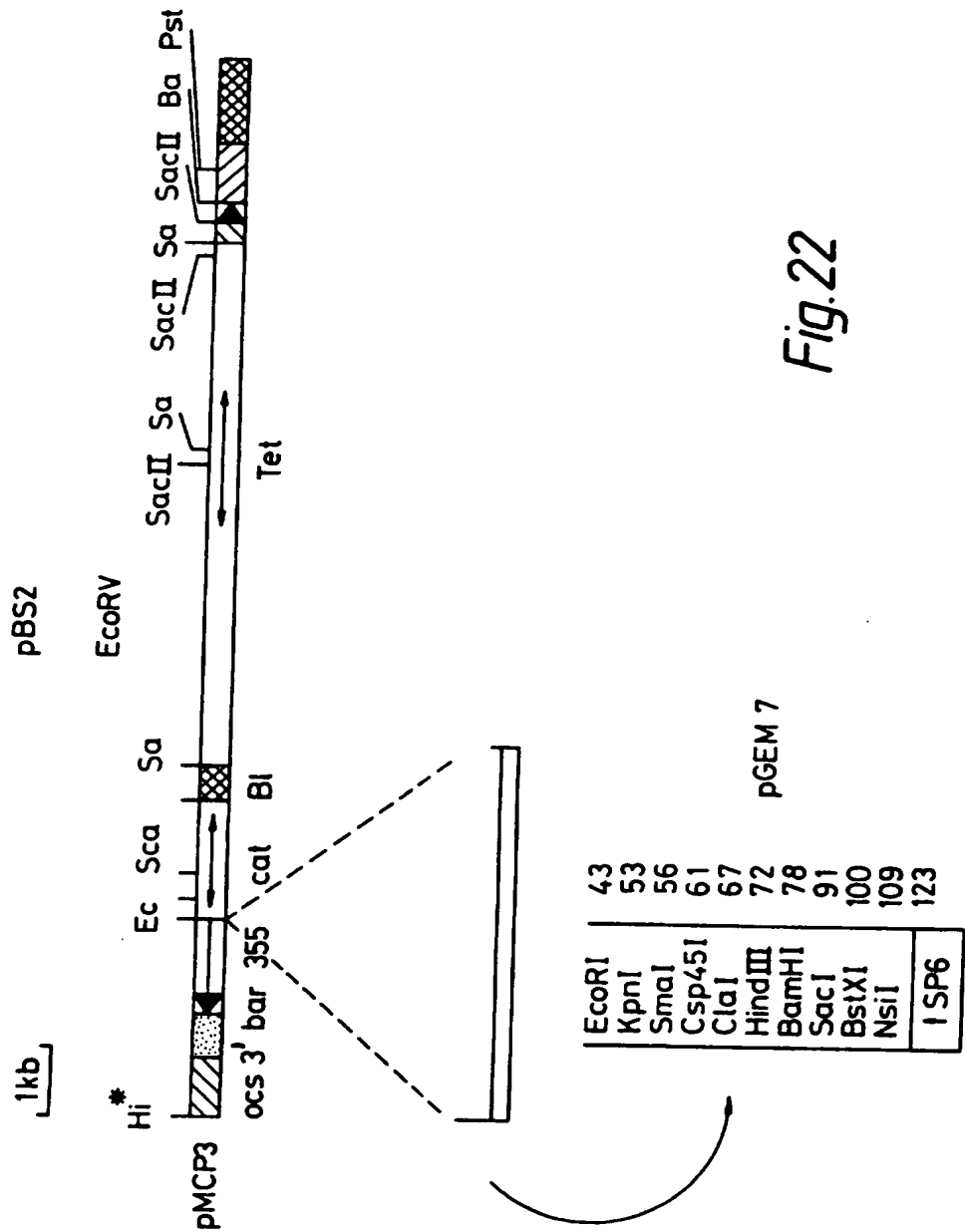


Fig. 20

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/AU 95/00552

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl⁶: C12N 15/11 15/83, A01H 5/00 5/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See electronic data base box below

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
BIOTECHNOLOGY ABSTRACT (BIOT) see electronic data base box below

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent databases - WPAT, JAPIO, USPM and BIOT - the following key words were used in the online search:
CIRCOVIRUS## or CIRCO () VIRUS## or SUBTERRAN: () CLOVER () STUNT VIRUS## or SCSV or
COCONUT (5W) FOLIAR () DECAY () VIRUS## or CFDV or BANANA () BUNCHY () TOP () VIRUS## or
BBTV or (MILK () VETCH or MILKVETCH) () DWARF () VIRUS## or MDV or FABA () BEAN ()
NECTROTIC () YELLOW () VIRUS## or FBNYV

continued

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE, 4306832 (Max-Planck Gesellschaft zur Förderung der Wissenschaften) 24 February 1994: whole document especially page 2 lines 55 - page 3 line 18 examples I.2 - examples II.3 and figures 1-3	1-2, 5, 9-12, 19, 28-31, 36
P,X	Virology volume 207 pages 354-361 (1995) P. Boevink et al "Sequence of subterranean clover stunt virus DNA: Affinities with geminivirus". See pages 356- 357 and figures 1 and 2	1-7, 19-22, 37



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search
1 December 1995

Date of mailing of the international search report

17 DECEMBER 1995

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INTERNATIONAL SEARCH REPORTInternational Application No.
PCT/AU 95/00552

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	Journal of General Virology (1995) volume 76, pages 574-479, Katul Lina et al "Sequence analysis of a Faba bean necrotic yellow virus DNA component containing a putative replicase gene". See especially pages 476-477 figures 1 and 3	1
P,X	Journal of General Virology (1994) volume 75, pages 3541-3546 Karan Mirko et al "Evidence for two groups of banana bunchy top virus isolates". See especially figure 1, page 3544, lines 14-23	1
X	Phytopathology volume 84, no. 9 issued 1994, pages 952-958 WU R.Y et al "Nucleotide sequences of two circular single-stranded DNAs associated with banana bunchy top virus. See especially page 956	1
P,X	Phytopathology volume 85, no. 3 (1995), Xie W.S. and Hu J.S. "Molecular cloning sequence analysis and detection of banana bunchy top virus in Hawii". See page 344	1
A	Virus Research Volume 27 (1993) pages 161-171 Chu Paul W.G. et al "Putative full-length clones of the genomic DNA segments of subterranean clover stunt virus and identification of the segment coding for the viral coat protein".	
A	Virus Research volume 27 (1993) pages 173-183 Chu Paul W.G. et al "Replication of subterranean clover stunt virus in pear and subterranean clover protoplasts"	

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/AU 95/00552

Box B FIELDS SEARCHED - Electronic data base (continued)

STN database - Chemical abstracts (CAS ONLINE):

(1) The following key words were used in the online search:

(CIRCOVIRUS? or CIRCO()VIRUS? or CLOVER()STUNT()VIRUS? or FOLIAR()DECAY()VIRUS? or
?VETCH()DWARF()VIRUS? or BANANA()BUNCHY()TOP()VIRUS? or
BEAN()NECROTIC()YELLOW()VIRUS?) AND 3/CC

(2) The following nucleic acid sequences have been searched as fragments together with the specified key words:

(TACATACTCA or TACTGGACAG or TACAGCTATA or TACTCAGTAC or GATTGTGGGT or
TAGAGTAGCT or GCTATAAATA) and PROMOTER#/TT and 3/CC and not P/DT.

(3) The following nucleic acid references have been searched as fragments:

GTTGTCTTGGGTCTATAAA; TATCAATTGTTGAATAAA; TTAAATGAGTGGCTATAAA;
CTTCGTGGCTTTATAAA; TTGATTGTGGGTATAAA; TGAAGATAGAATAAA; TAATGAGTGGCTATAAA.